NRC MOV Course

Theory of Operation

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Theory of Operation of MOVs

Objectives

- Identify common valve types and their typical service applications.
- Describe the mechanical components that make up rising-stem valves.
- Describe the mechanical components that make up rotating-stem valves.
- Describe the major electrical and mechanical components that make up common motor actuators.
- Describe the electrical and manual modes of operation of motor actuators and trace the path of the rotational forces through the device.

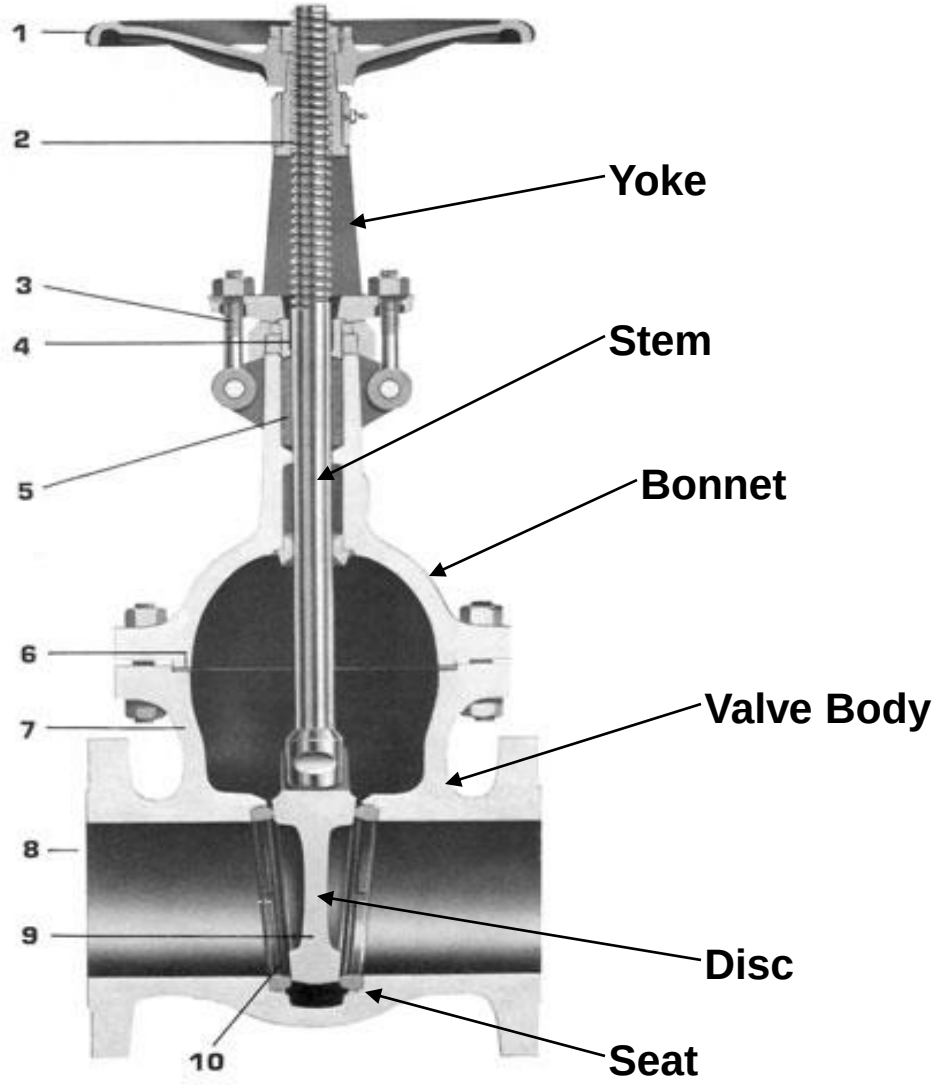
Introduction

- An MOV is a combination of two separate devices, usually provided by two separate manufacturers.
  - Valve Assembly

  a mechanical device to optimize a desired fluid control function, such as isolation or throttling.
  - Actuator

  an electrical/mechanical device used to position a valve assembly from a remote location.
- The basic parts of a valve assembly have common nomenclature regardless of the type of valve.
  - valve body, bonnet, disc (pressure boundary)
  - seat, stem, and yoke

Valve Assembly Basic Parts



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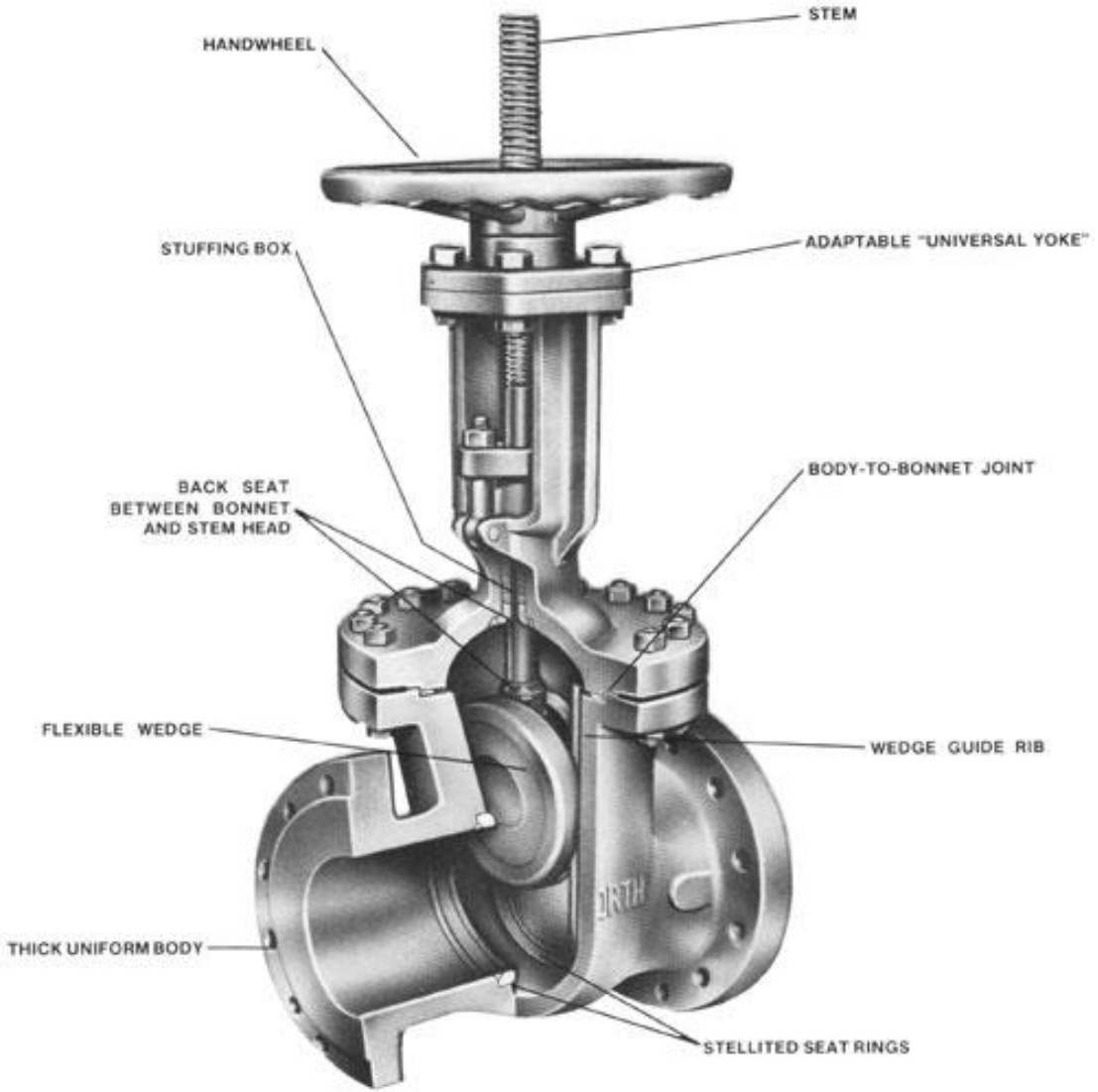
Rising-Stem Valves

- *Rising-Stem Valves are those designs operated by pushing or pulling the valve stem.*
- *The valve stems do not rotate.*
- *The valve stems are threaded and matched to a stem nut to convert the rotational output of the actuator to linear movement of the valve stem.*
- *Most common designs are gate and globe valves.*

Gate Valves

- Gate valves are used to start or stop flow, but are not intended to regulate or throttle flow.
- The name “gate” comes from the appearance of the disc in the flow stream.
- Gate valves are most often found in flow isolation applications
  - Used at any system pressure
  - Common in large diameter, higher pressure piping systems.
  - Often have a closing safety function such as containment isolation or an opening safety function such as emergency core cooling.

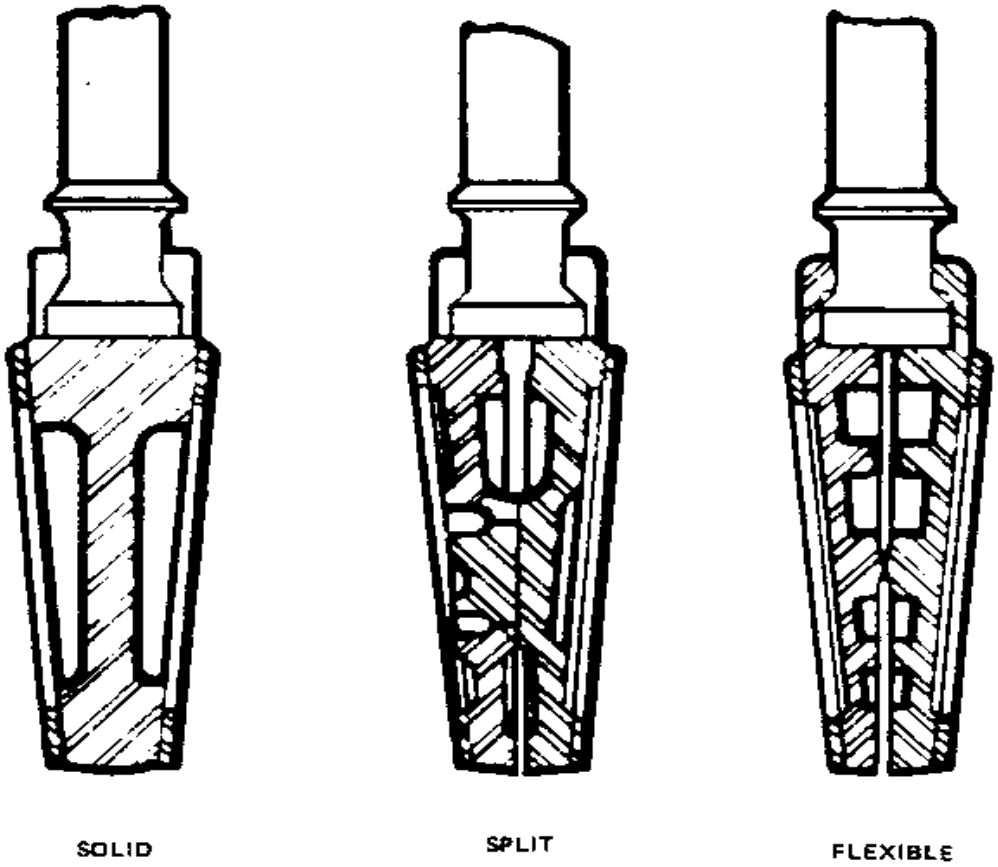
Typical Gate Valve



Gate Valve Disc Designs

- Gate valve discs may be parallel or wedge design.
  - Parallel discs have seating surfaces that are parallel to each other and perpendicular to the flow path.
  - Wedge discs have angled seating surfaces which form a “V” shape that wedges the disc between the seat rings.
  - Wedge discs can be solid, split, or flexible.
- Gate valve discs typically provide seating on both the upstream and downstream seats.

Gate Valve Wedge Discs



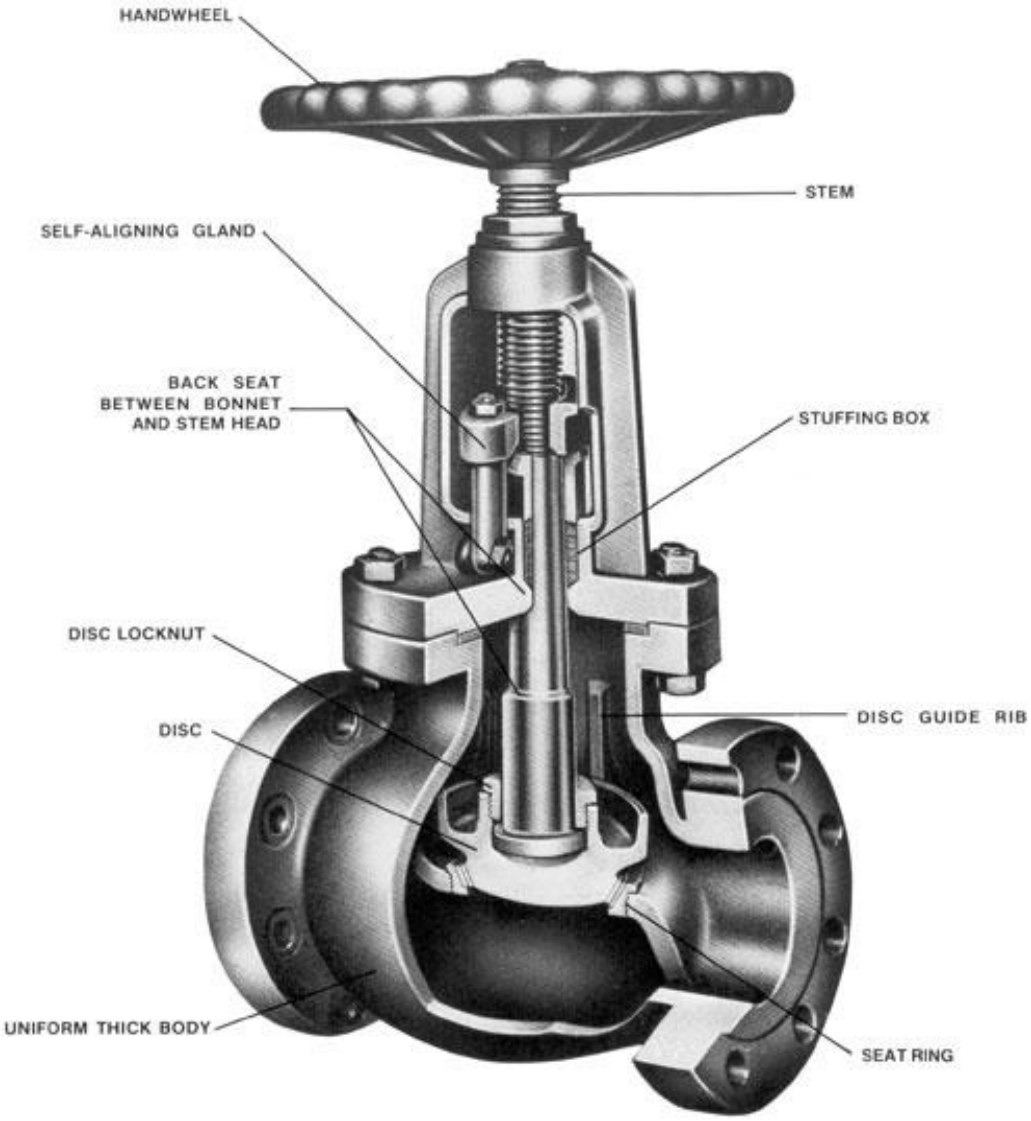
Globe Valves

- Globe valves are used to stop, start, and regulate fluid flow.
- The name “globe” is derived from the shape of the disc which can be similar to a globe.
- The disc more often looks more like a plug.
  - (can lead to confusion with true plug valves which are quarter-turn valves)
- Globe valves can be designed so that, a large flow area is realized around the disc with small stem movement.
  - This allows a quick opening or closing function.
- Globe valves and be designed so that the flow area gradually changes with stem movement.
  - This gives the globe valve good throttling ability for use in regulating flow.

Globe Valve Orientation

- Globe valves can be installed with flow over or under the disc.
- Closing against the direction of the fluid flow (flow under disc) impedes closing but aids in opening the valve.
- Closing in the same direction as the fluid flow (flow over disc) aids closing but impedes opening the valve.
- This characteristic makes globe valves well suited for fail-open or fail-close valve applications

Typical Globe Valve



Quarter-Turn Valves

- *Quarter-turn valves are those designs operated by turning the valve stem 90 degrees.*
- *Valve discs rotate with the valve stem to open or close the flow path.*
- *Valve stems are driven directly by the rotational motion of the actuator.*
- *Most common designs are ball, plug, and butterfly valves.*

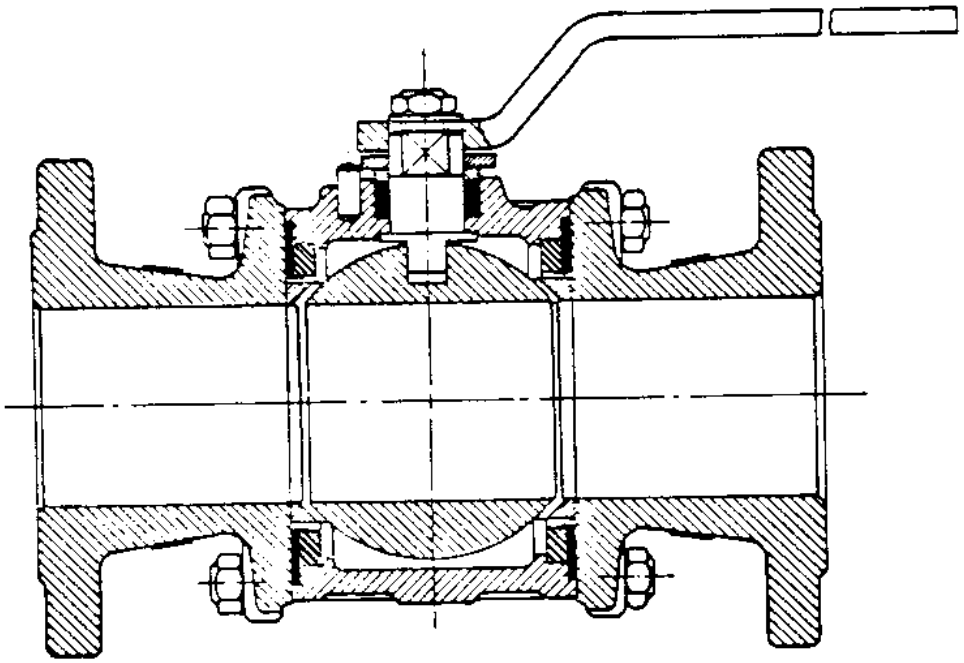
Ball And Plug Valves

- Ball and plug valves are used to stop or start fluid flow.
- The names are derived from the shape of the disc which resembles a ball or a plug.
- In the open position, the ball/plug provides an unobstructed flow path through the valve.
- In the closed position, the ball/plug is turned 90 degrees, blocking the ports and stopping fluid flow.

Ball And Plug Valves

- Advantages:
  - Little resistance to operation
  - Differential pressure has little effect on operating loads
  - Quick opening and closing
  - Designed for any system pressure.
- Disadvantages:
  - Higher cost
  - Rapid wear and corrosion of seats
  - Inability to regulate flow
  - Weight of the ball or plug in large diameter systems

Typical Ball Valve



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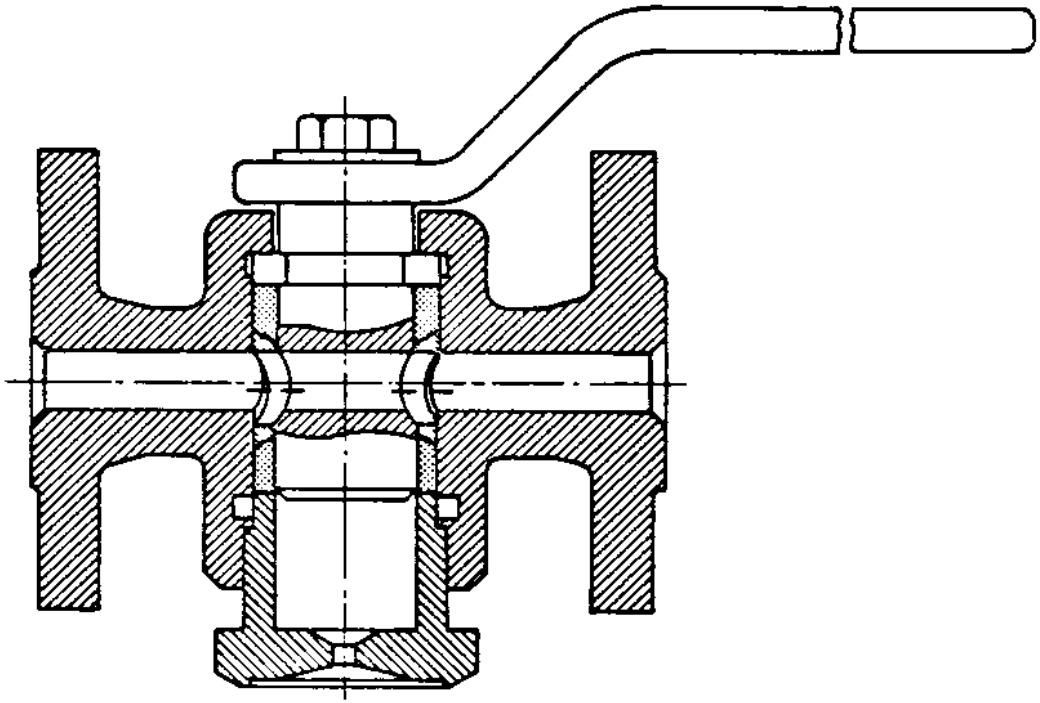
Typical Plug Valve



Butterfly Valves

- Butterfly valves are used to stop, start, and regulate fluid flow.
- The valve stem extends completely through the valve body.
- The disc is a flat or slightly curved disc attached to the valve stem.
- The disc is rotated 90 degrees about an axis at a right angle to fluid flow
- The seats are typically a soft, resilient seat made of rubber or neoprene..

Butterfly Valves

- In the fully open position, little resistance to flow exists and pressure loss is minimal.
- In the fully closed position little seat leakage occurs provided the resilient seat is in good condition.
- At intermediate positions, throttling of the fluid flow occurs although the flow regulating characteristics are not as good as that of globe valves.
- Butterfly valves are used in low pressure systems, such as circulating water systems.
- They are inexpensive and fairly easy to maintain.

Typical Butterfly Valve

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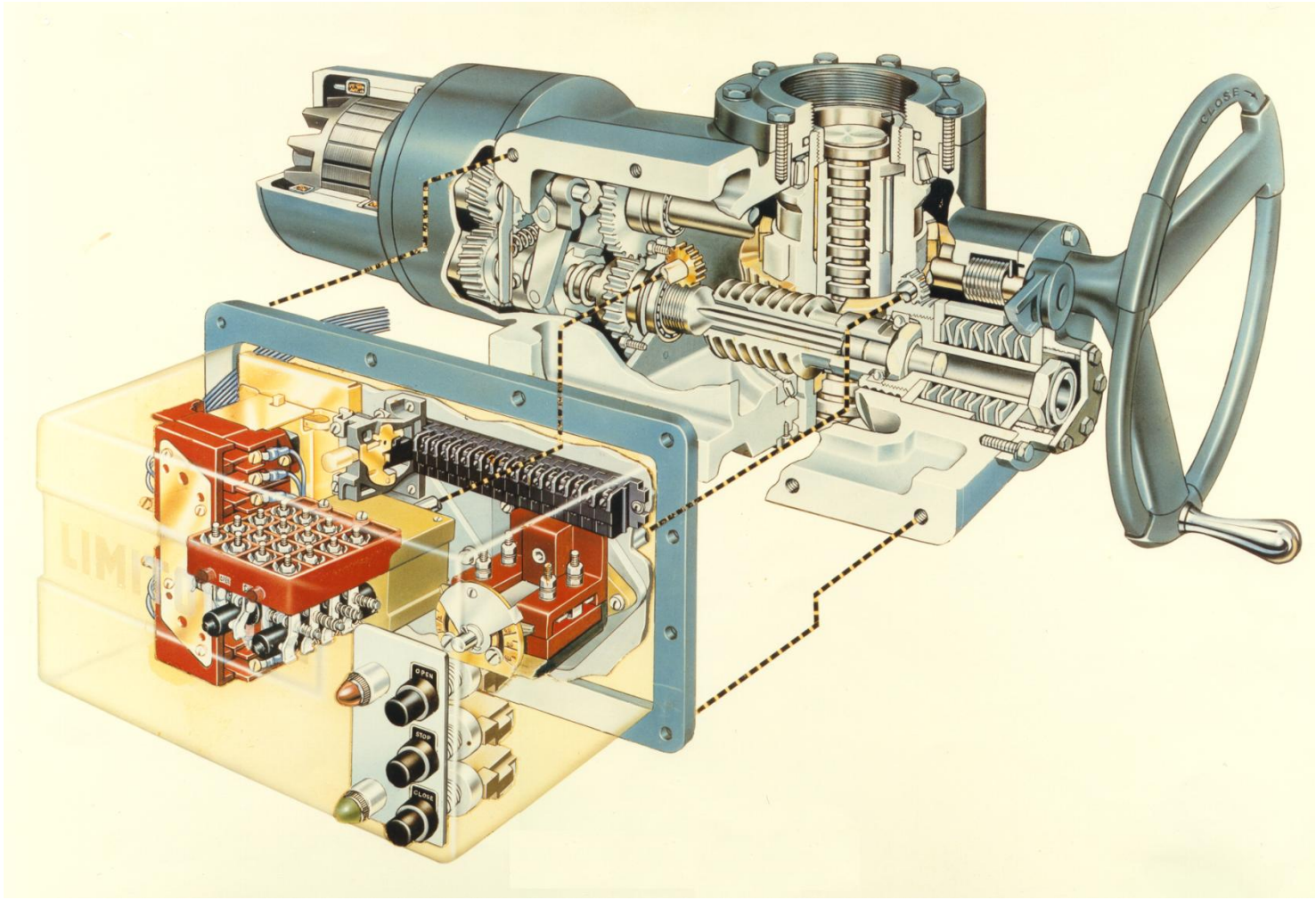
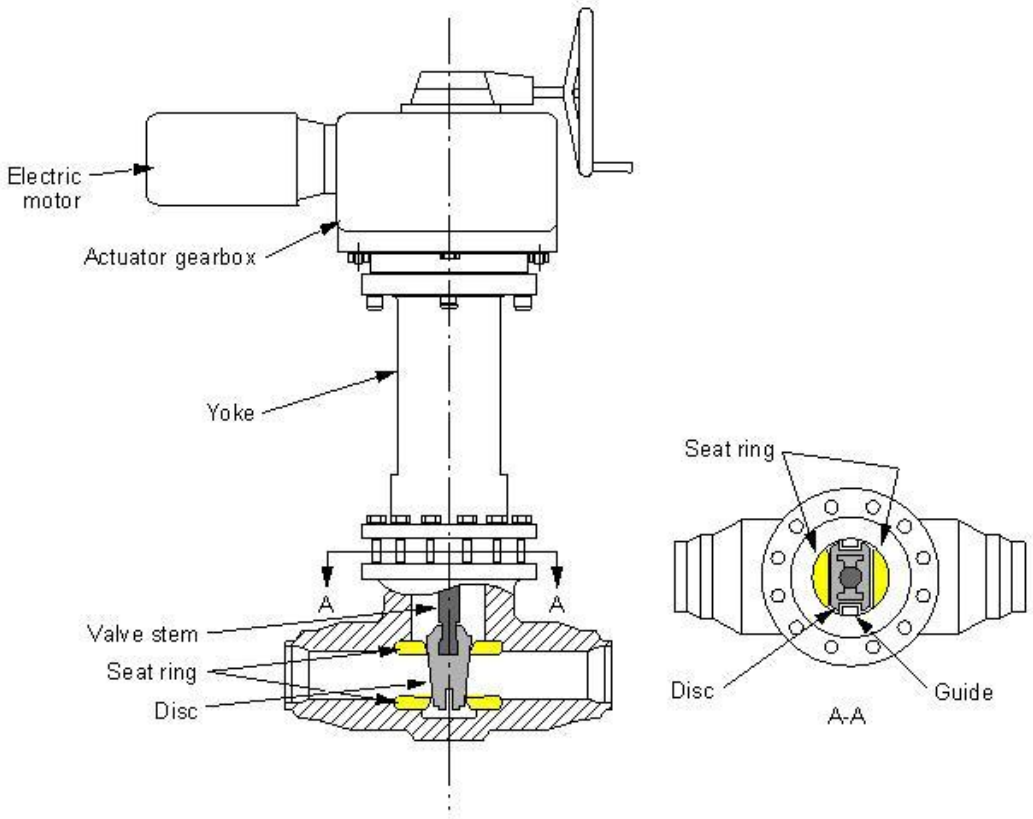
Valve Actuators

- The actuator operates the valve stem and disc assembly.
- Actuators for valve assemblies can be
  - manual handwheels
  - manual levers
  - motor operators
  - pneumatic operators
  - hydraulic operators
  - solenoid
- MOV Actuators used in US nuclear power plants are electro-mechanical devices, manufactured by
  - Limitorque
  - Rotork

Limitorque SMB Actuators



Limitorque Actuator on a Typical Gate Valve



Limitorque SMB Load Ratings

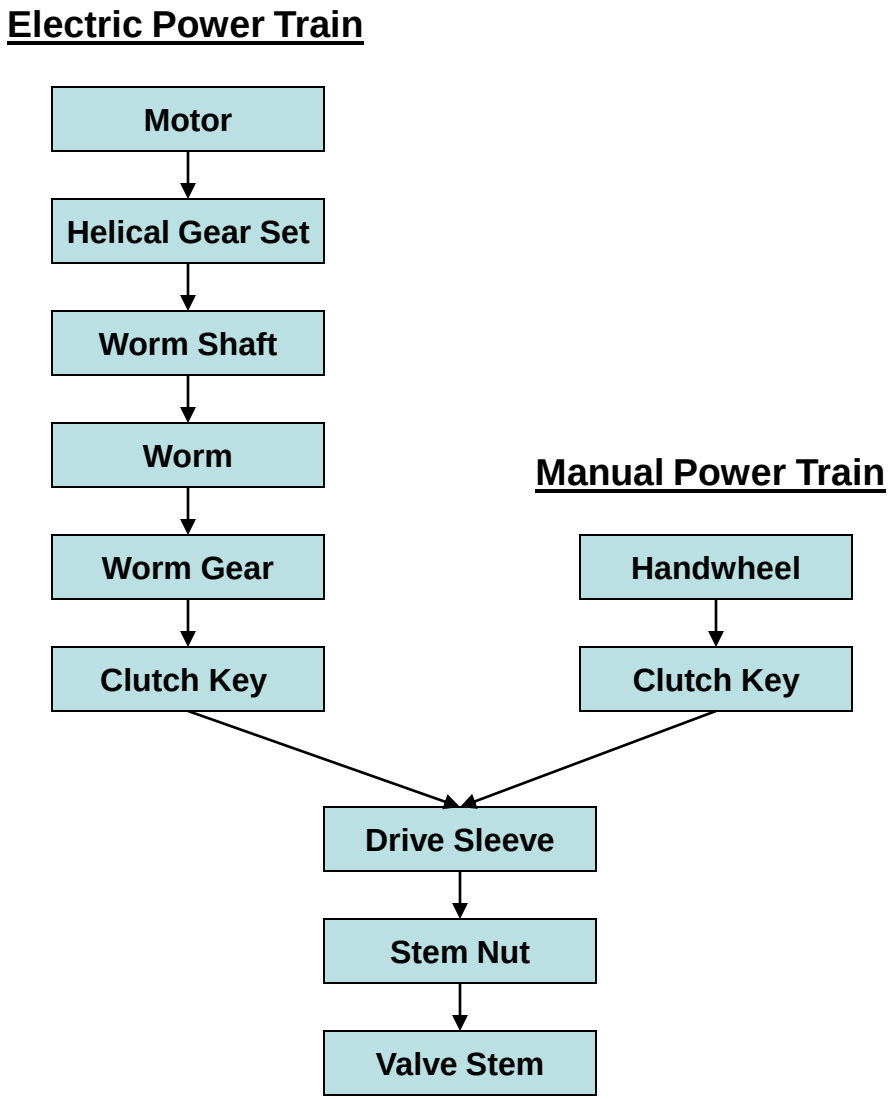
Type	Size	Nuclear Rating, ft-lb	Commercial Rating, ft-lb	Maximum Thrust, lb	Max Threaded Stem Dia., in
SMB	000	90	120	8,000	1-3/8
SMB	00	250	260	14,000	1-3/4
SMB	0	500	700	24,000	2-3/8
SMB	1	850	1,100	45,000	2-7/8
SMB	2	1,800	1,950	70,000	3-1/2
SMB	3	4,200	4,500	140,000	5
SMB	4 & 4T *	7,500	8,300	250,000	5
SMB	5 & 5T *	20,000	20,000	500,000	6-1/4

* The “T” in the size designation means a torque only application, no thrust capability.

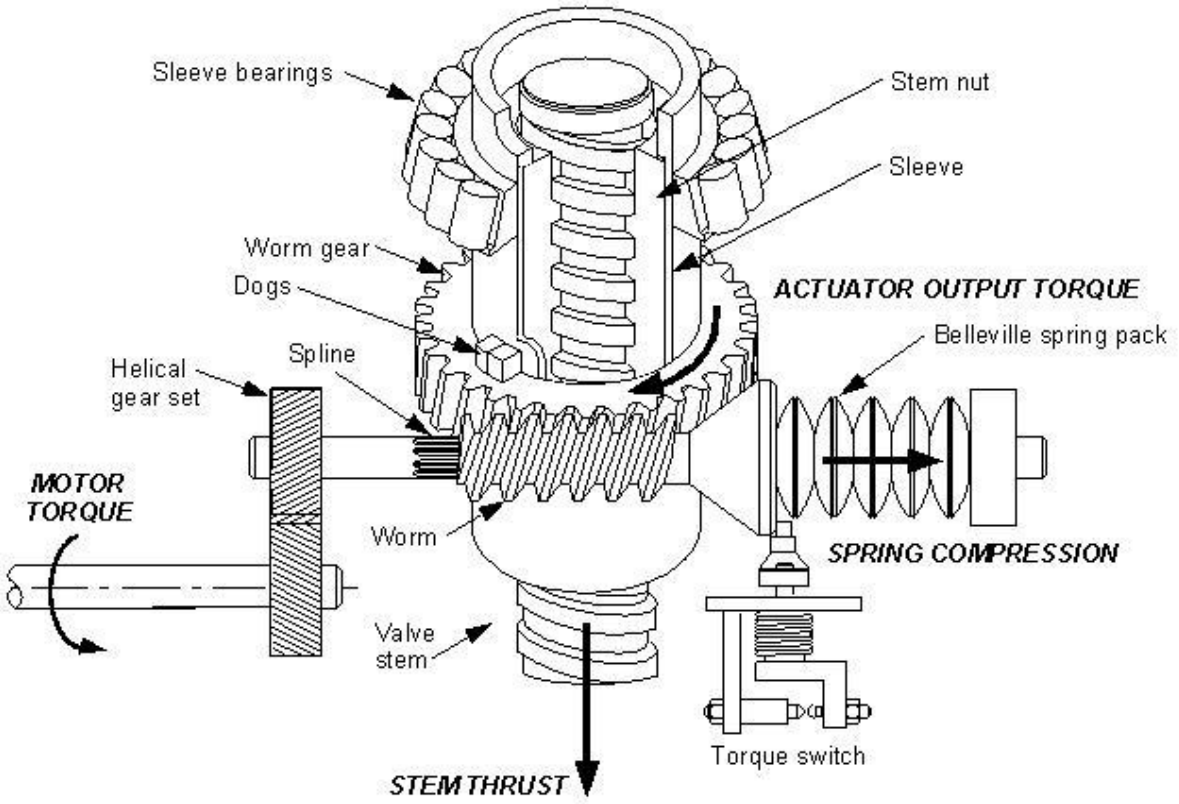
SMB Modes of Operation

- Electrical operation has electrical control for actuator motion. The actuator and valve are protected by the torque switch.
- Manual operation still has the indication, but the technician controls position.
- The two modes are separated by a clutching mechanism which prevents simultaneous operation.

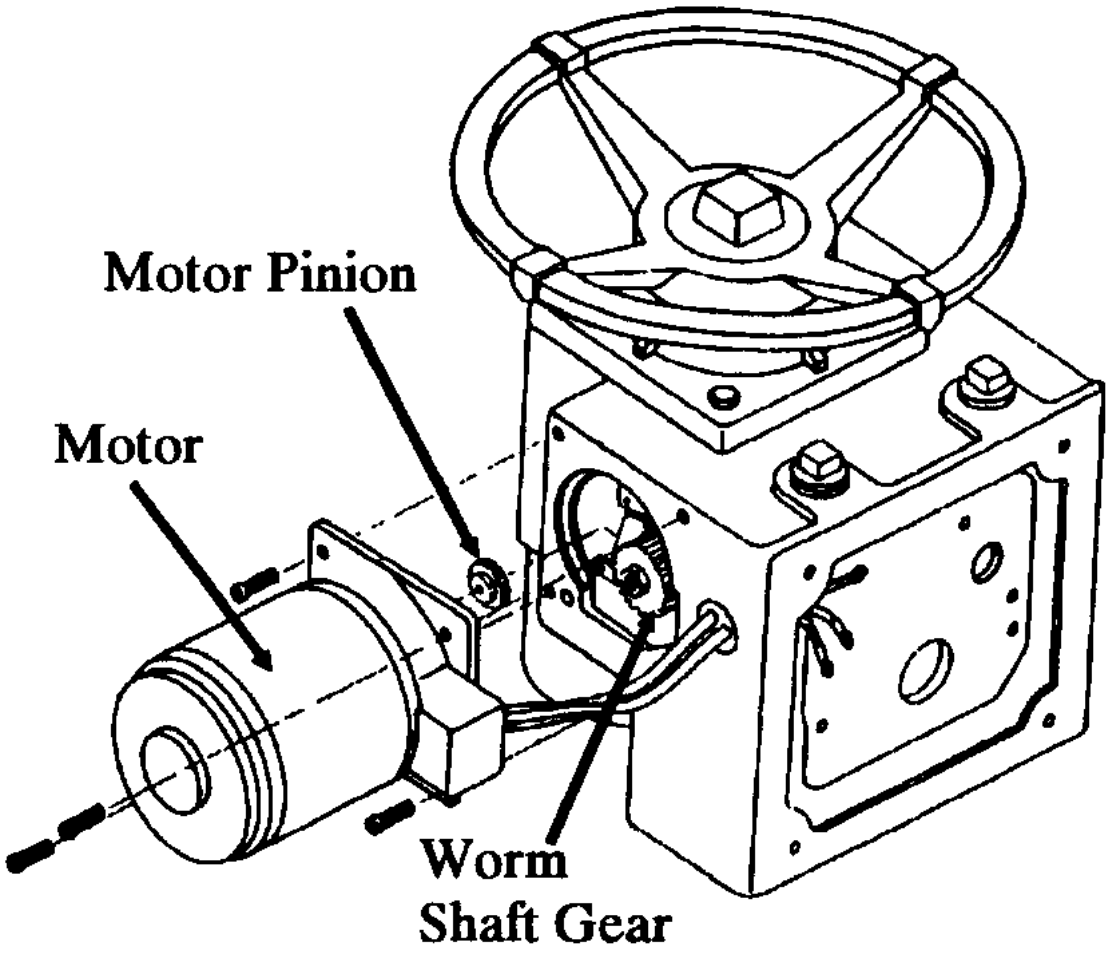
SMB-00/000 Power Trains



Limitorque Actuator Gear Train



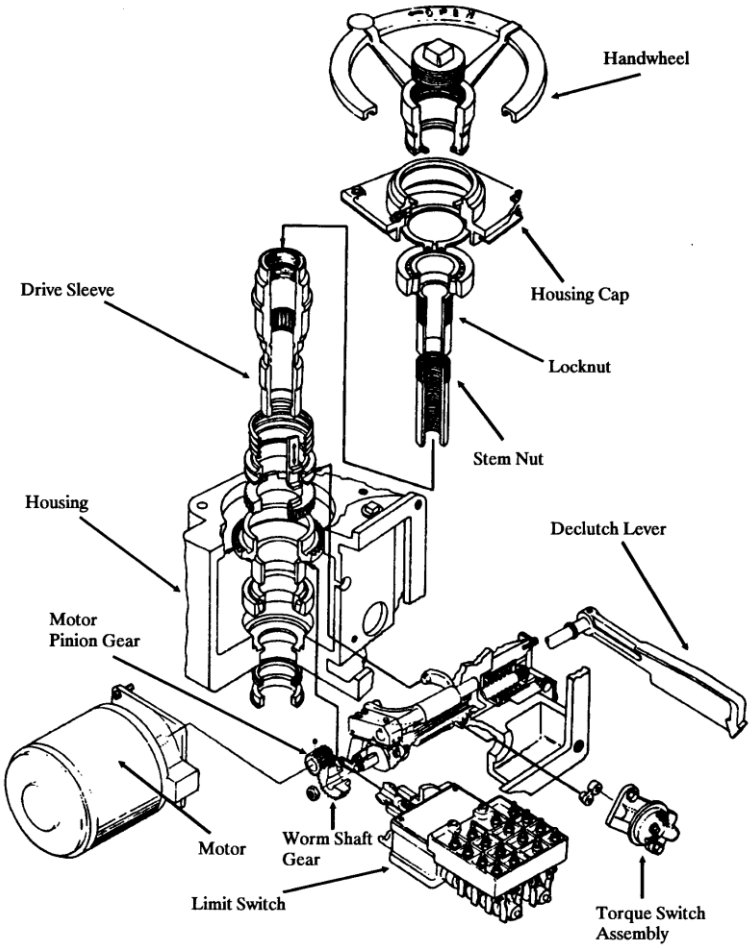
SMB-000 Motor



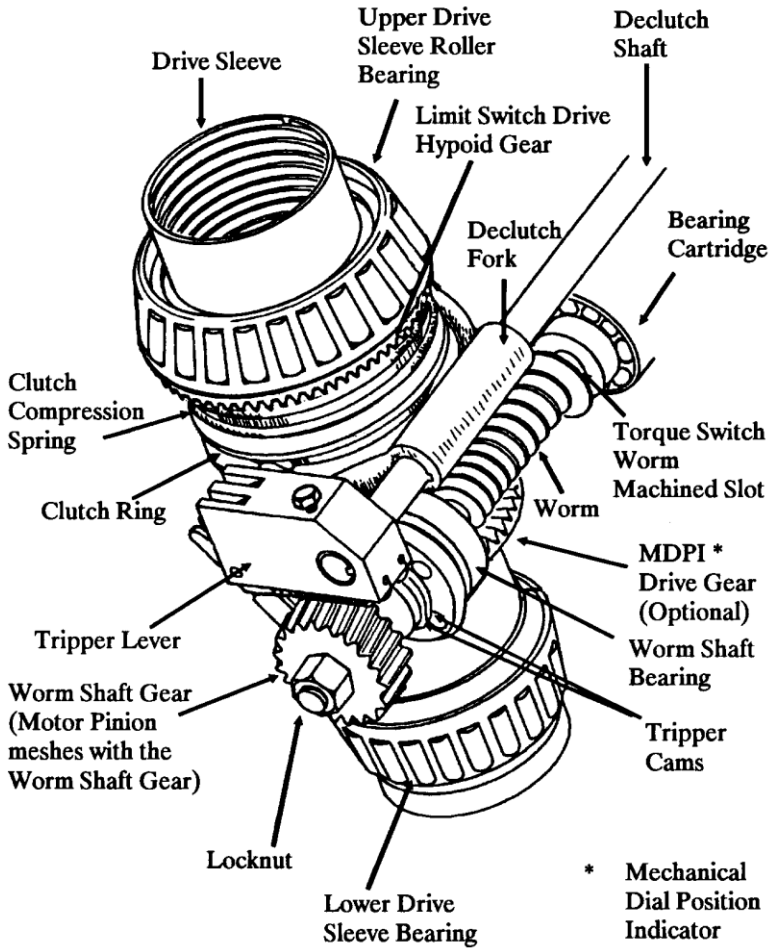
SMB Helical Gear Teeth Totals

SMB-000	45
SMB-00	65
SMB-0	72
SMB-1	72
SMB-2	70
SMB-3	60
SMB-4	72

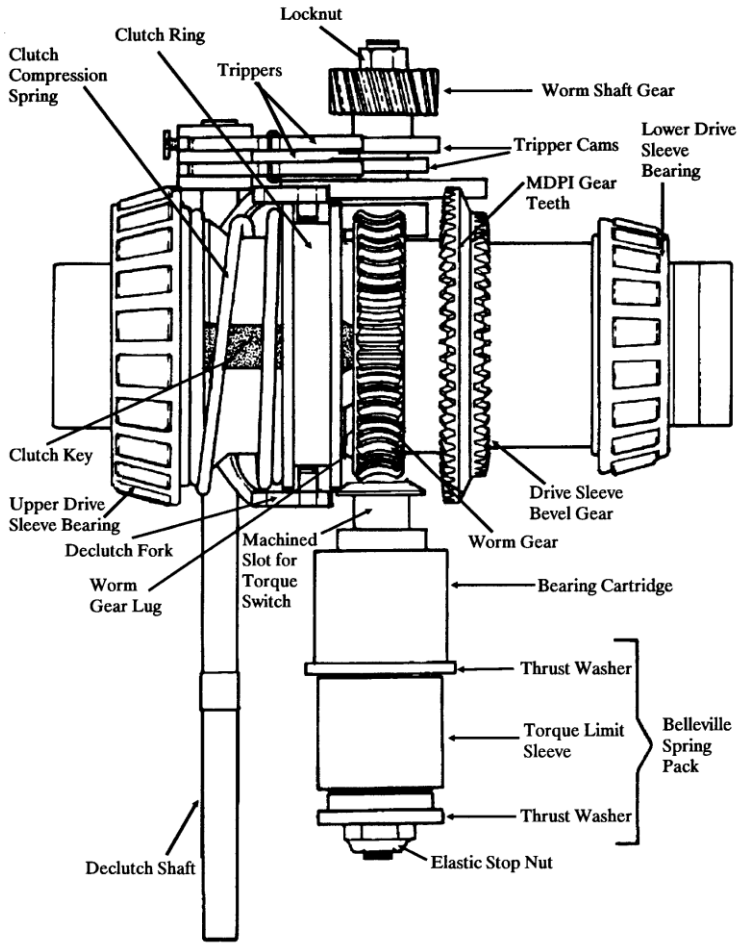
SMB-000 Exploded View



SMB-000 Electric Power Train



SMB-000 Electric Power Train – Side View



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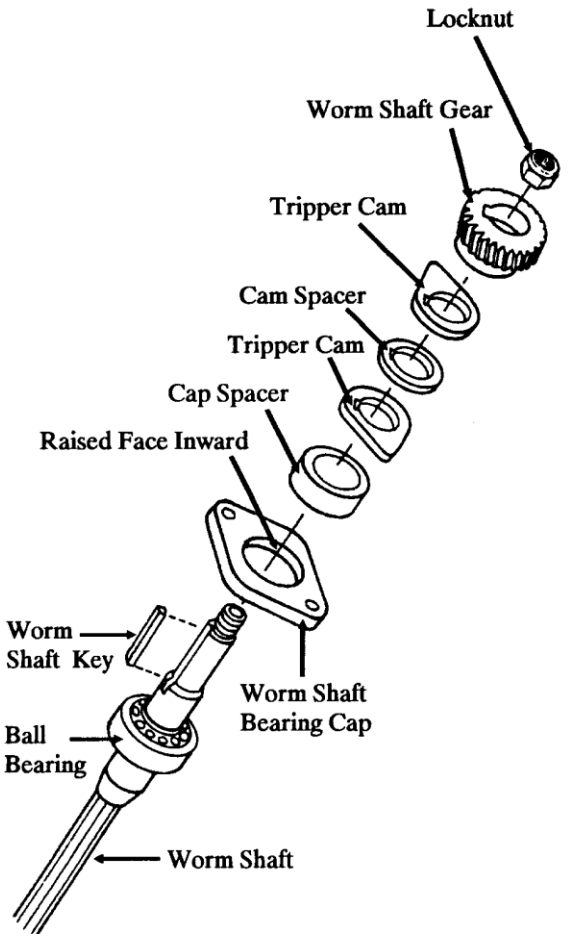
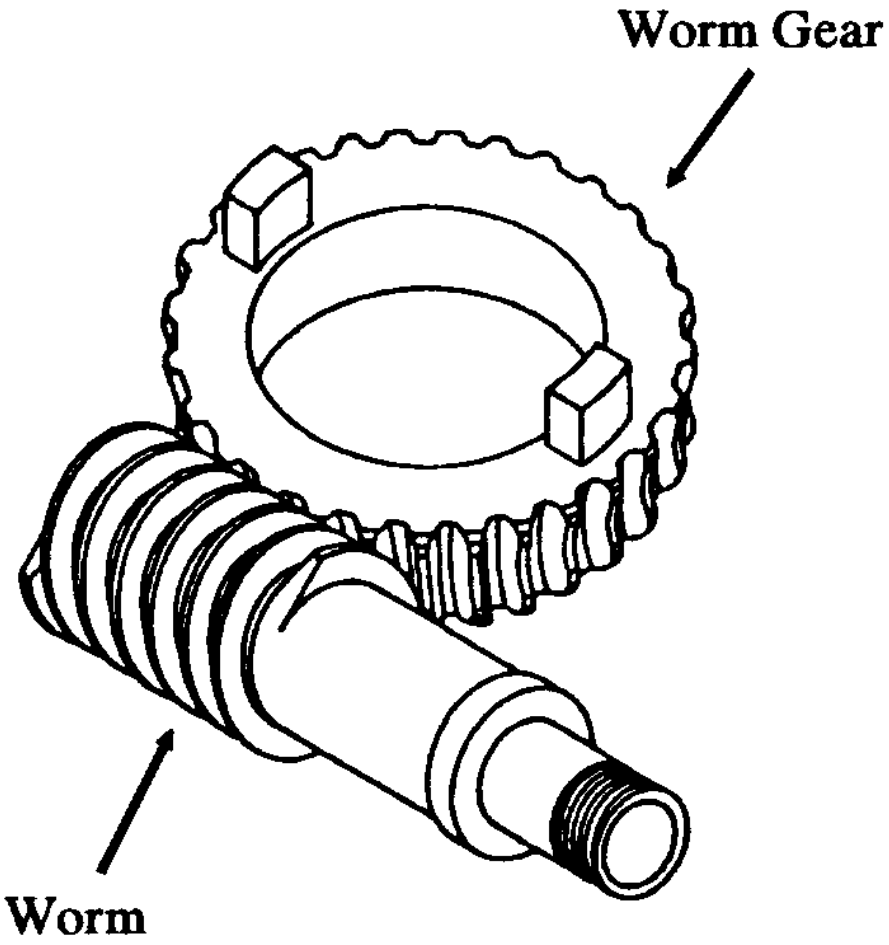
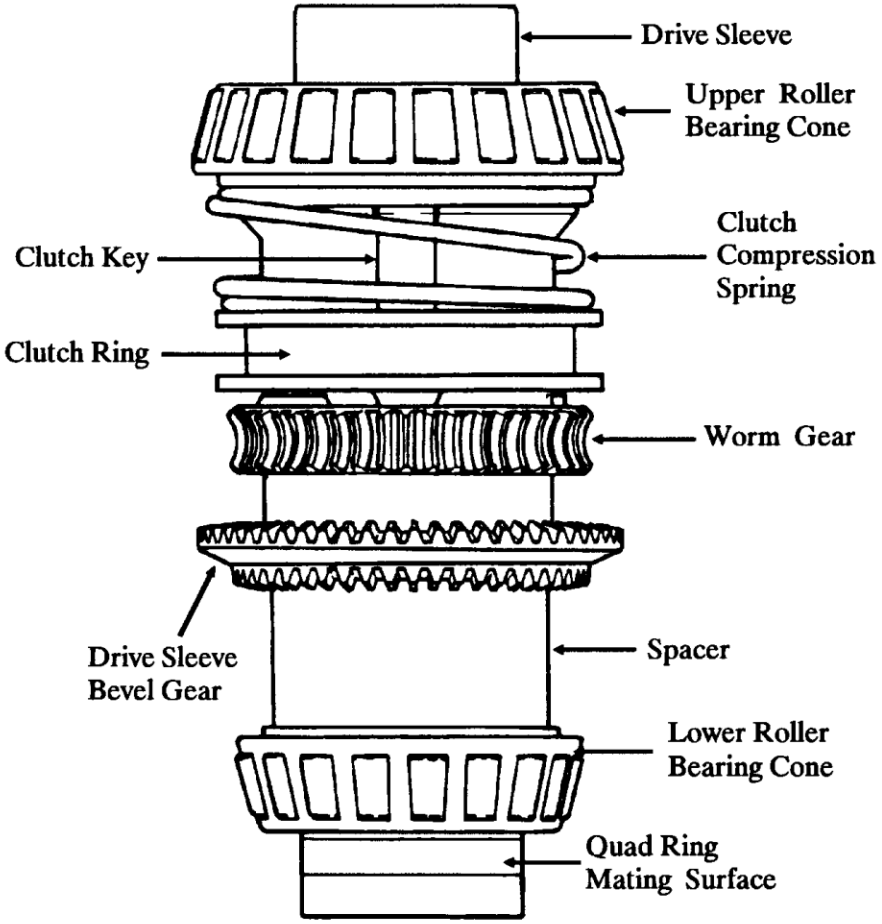
SMB-000/00 Worm Shaft Gear Assembly



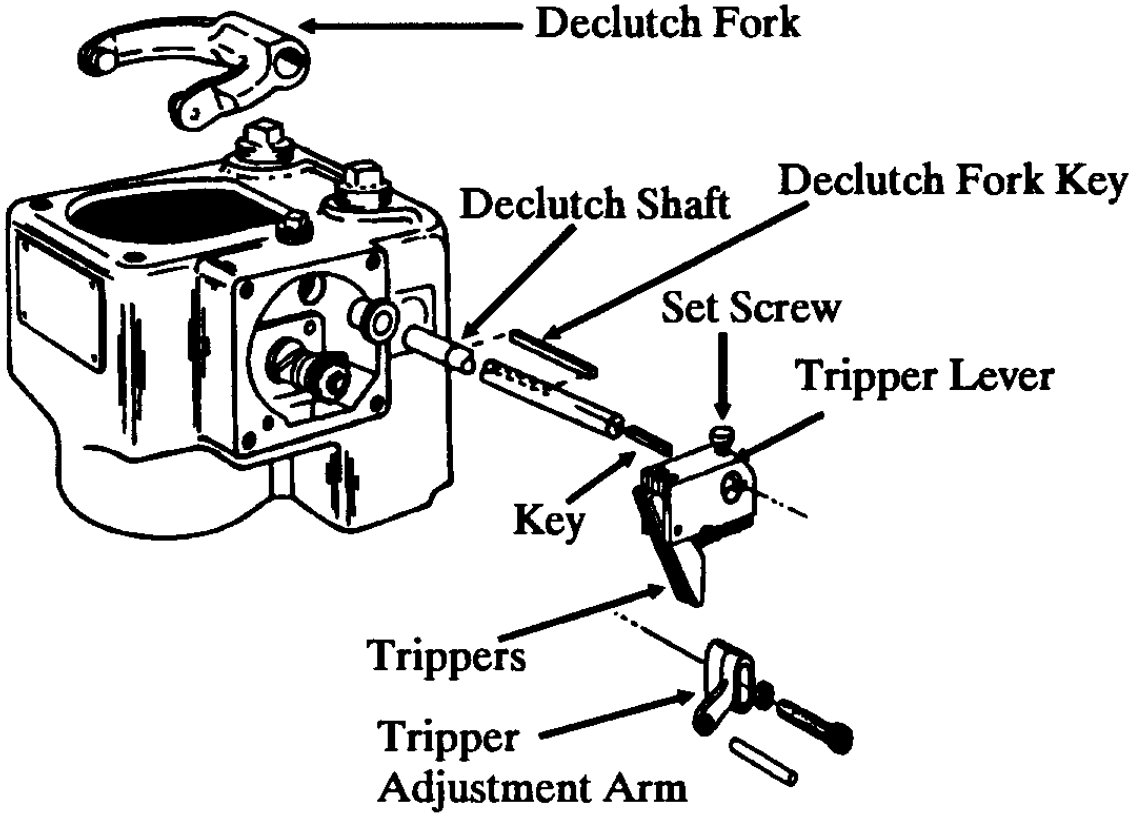
SMB-000/00 Worm and Worm Gear



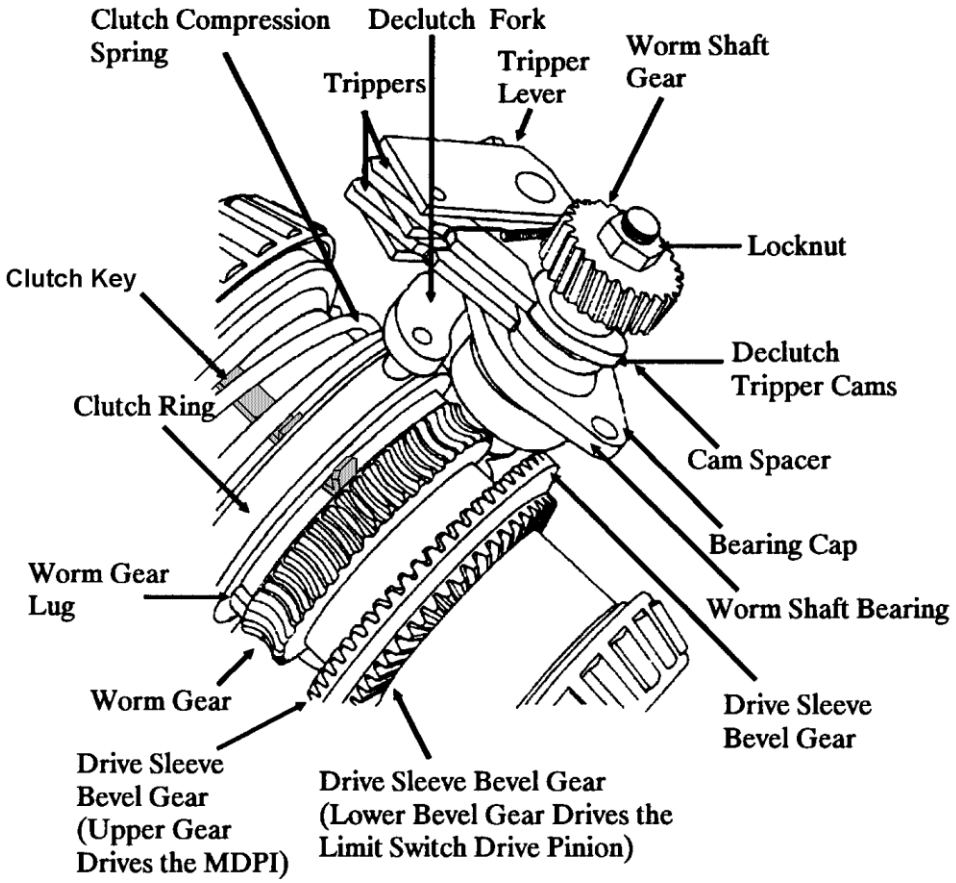
SMB-000 Drive Sleeve



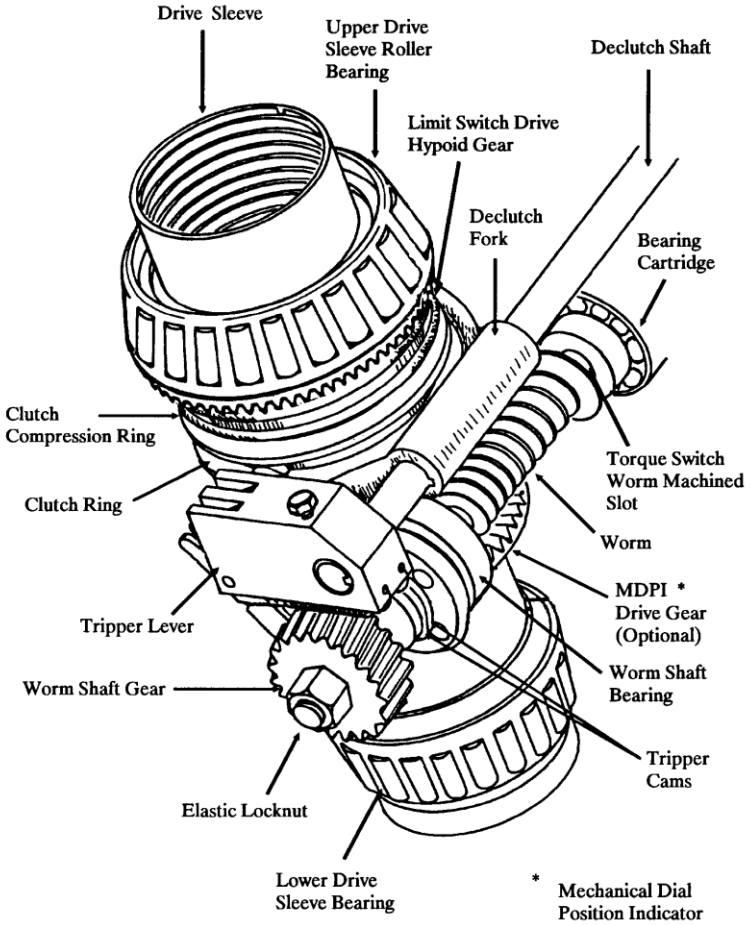
SMB-000/00 Declutch Mechanism



SMB-000 Actuator Drive Sleeve



SMB-00 Actuator Drive Sleeve



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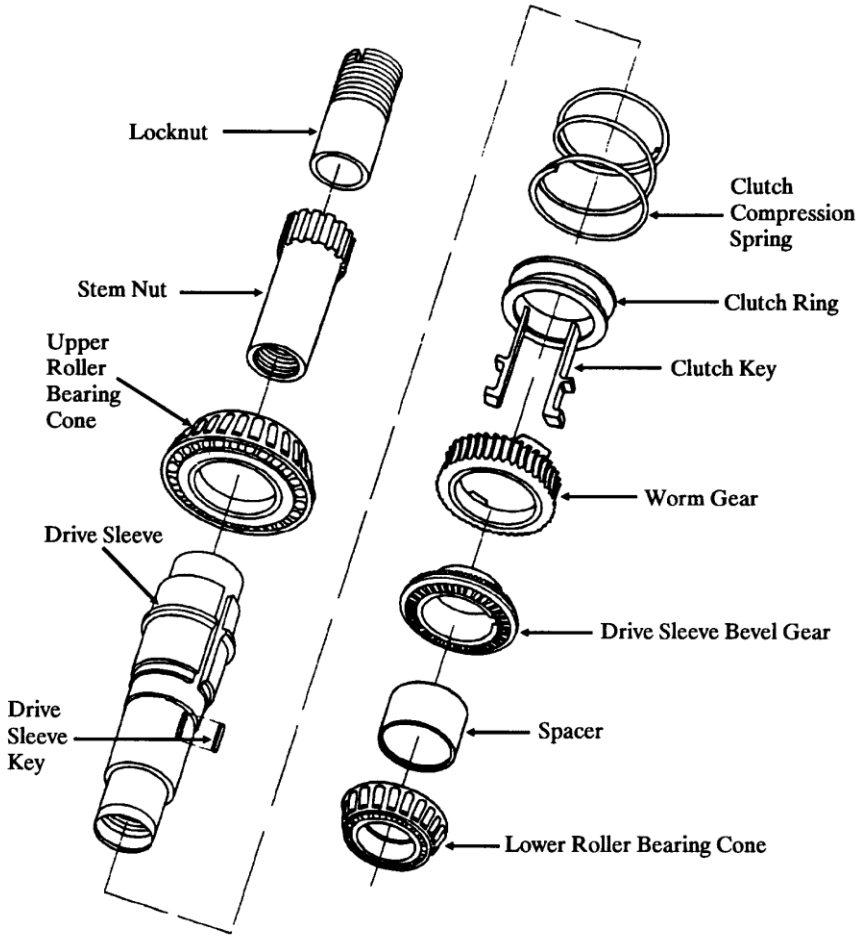
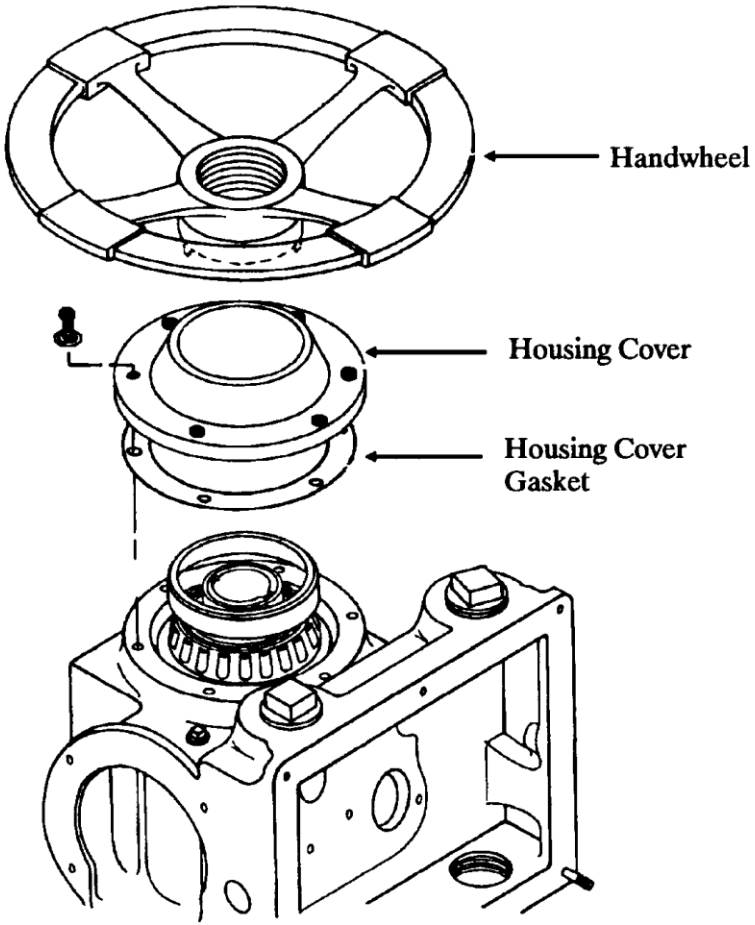
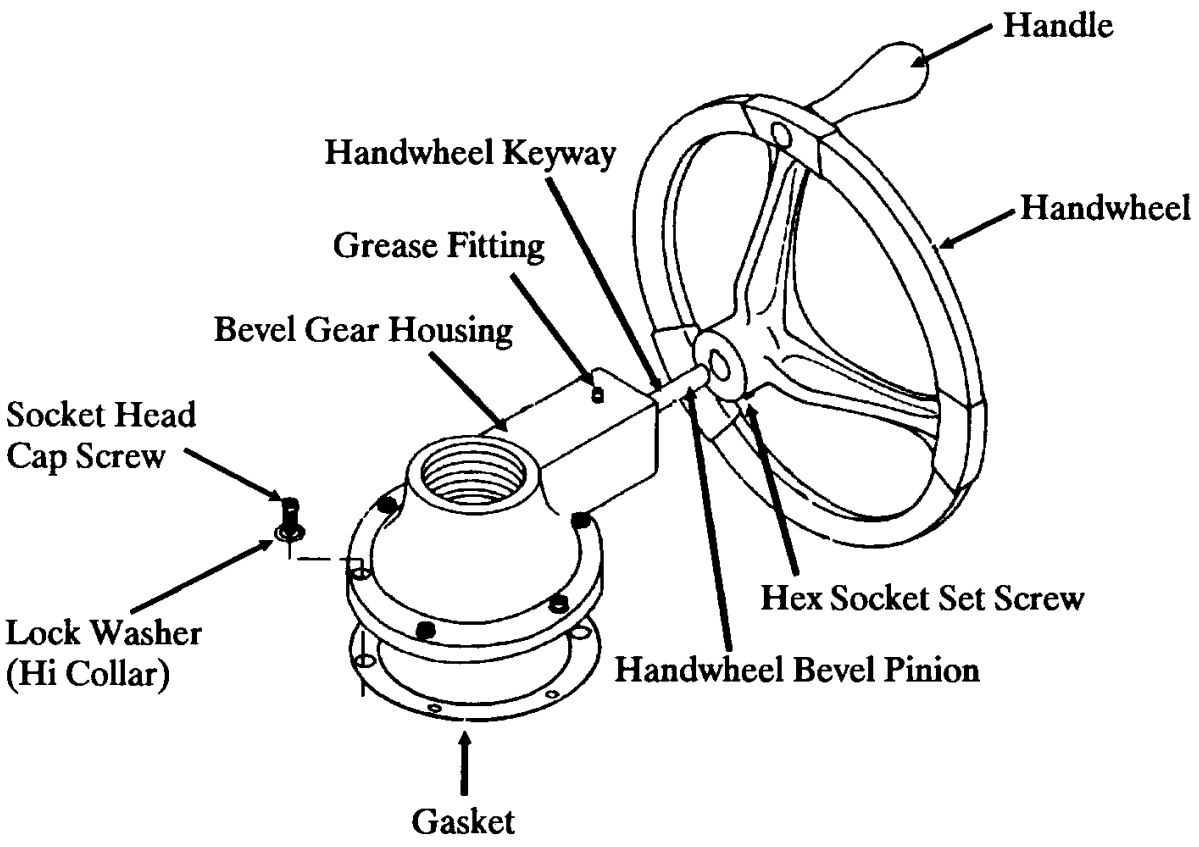
SMB-000/00 Drive Sleeve Exploded



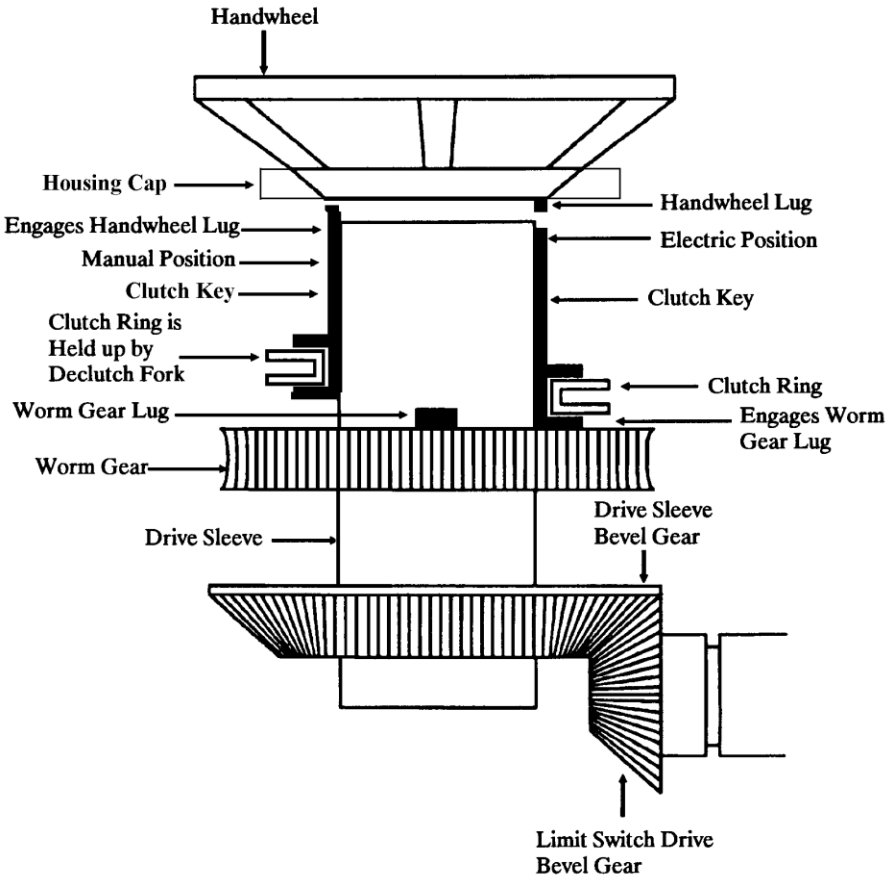
SMB-00 Top-Mounted Manual Power Train



SMB-00 Side-Mounted Manual Power Train



SMB-000/00 Handwheel Worm Gear Assembly



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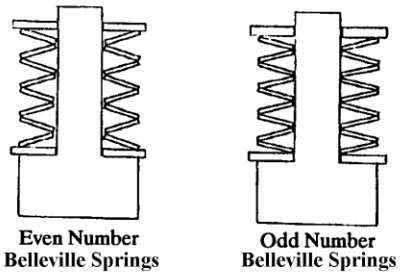
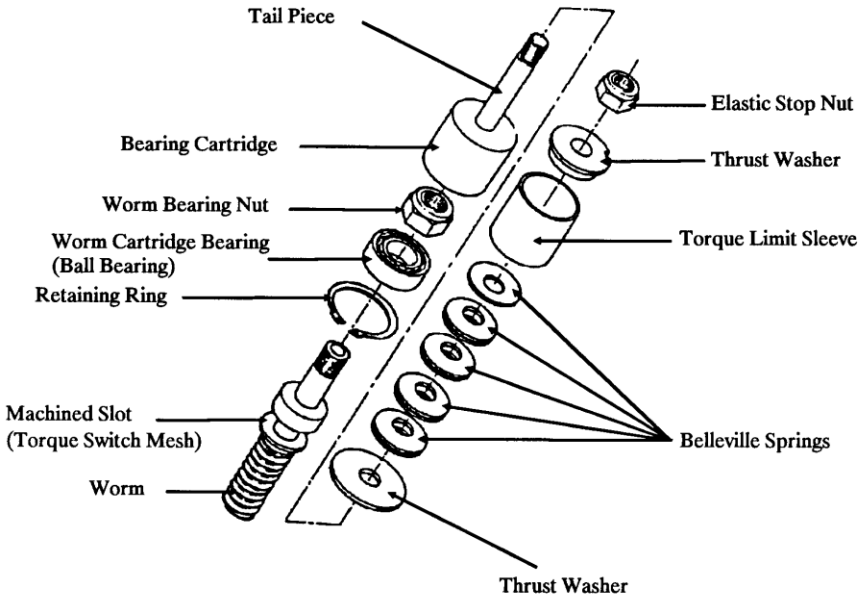
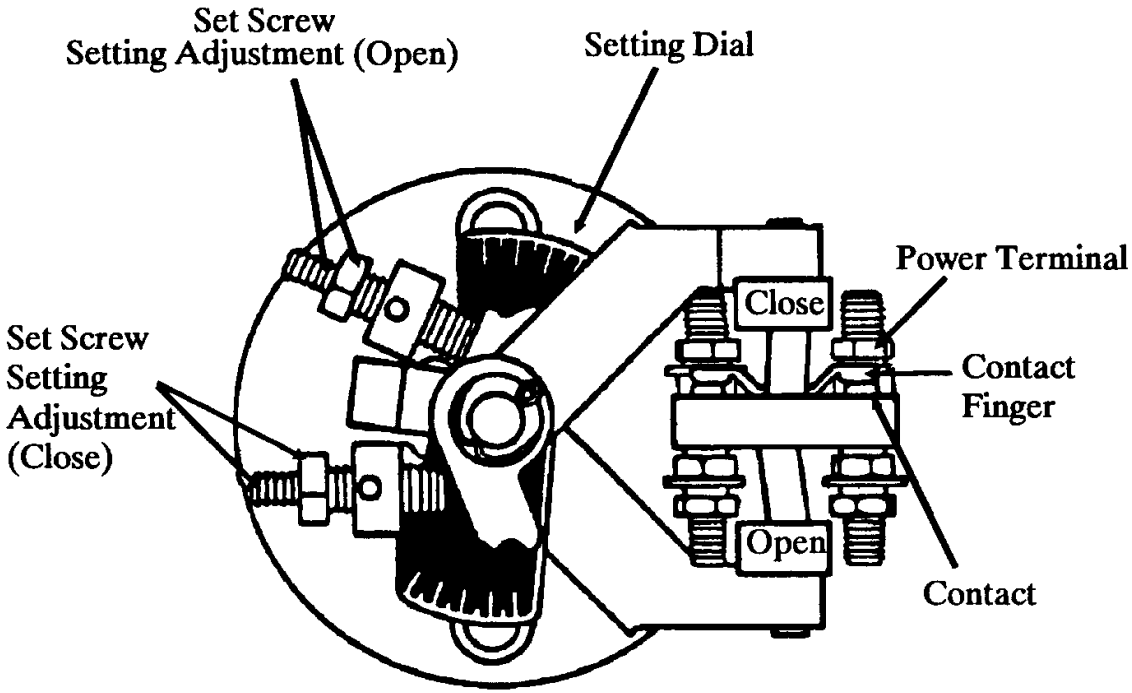
SMB-000/00 Worm/Belleville Spring Pack Assembly



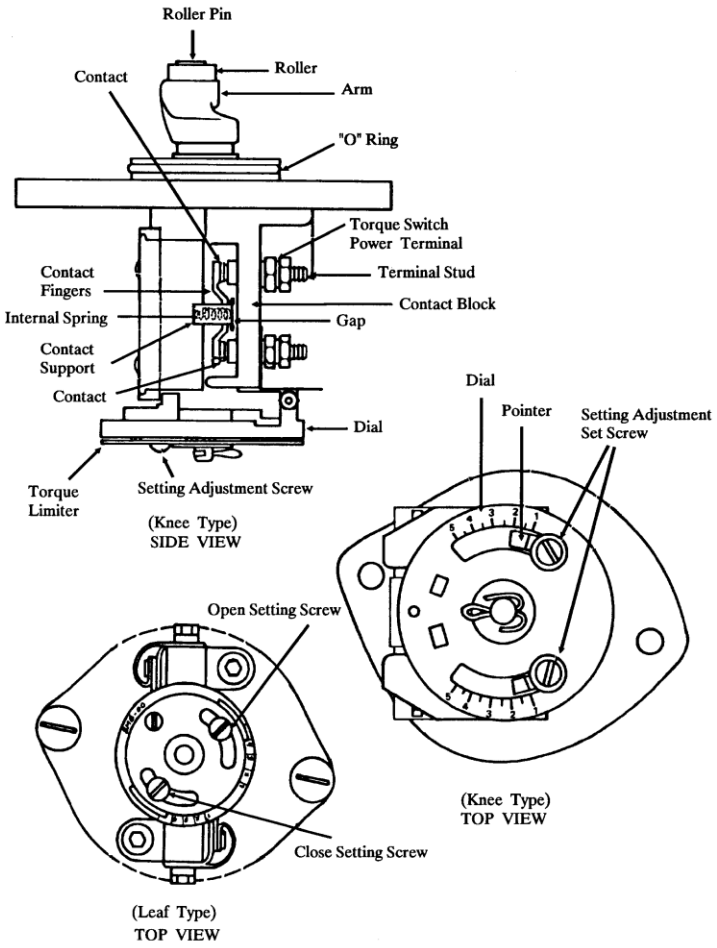


SMB-000/00 Scissor Action Torque Switch



TOP VIEW

Modified Leaf and Knee Type Torque Switch



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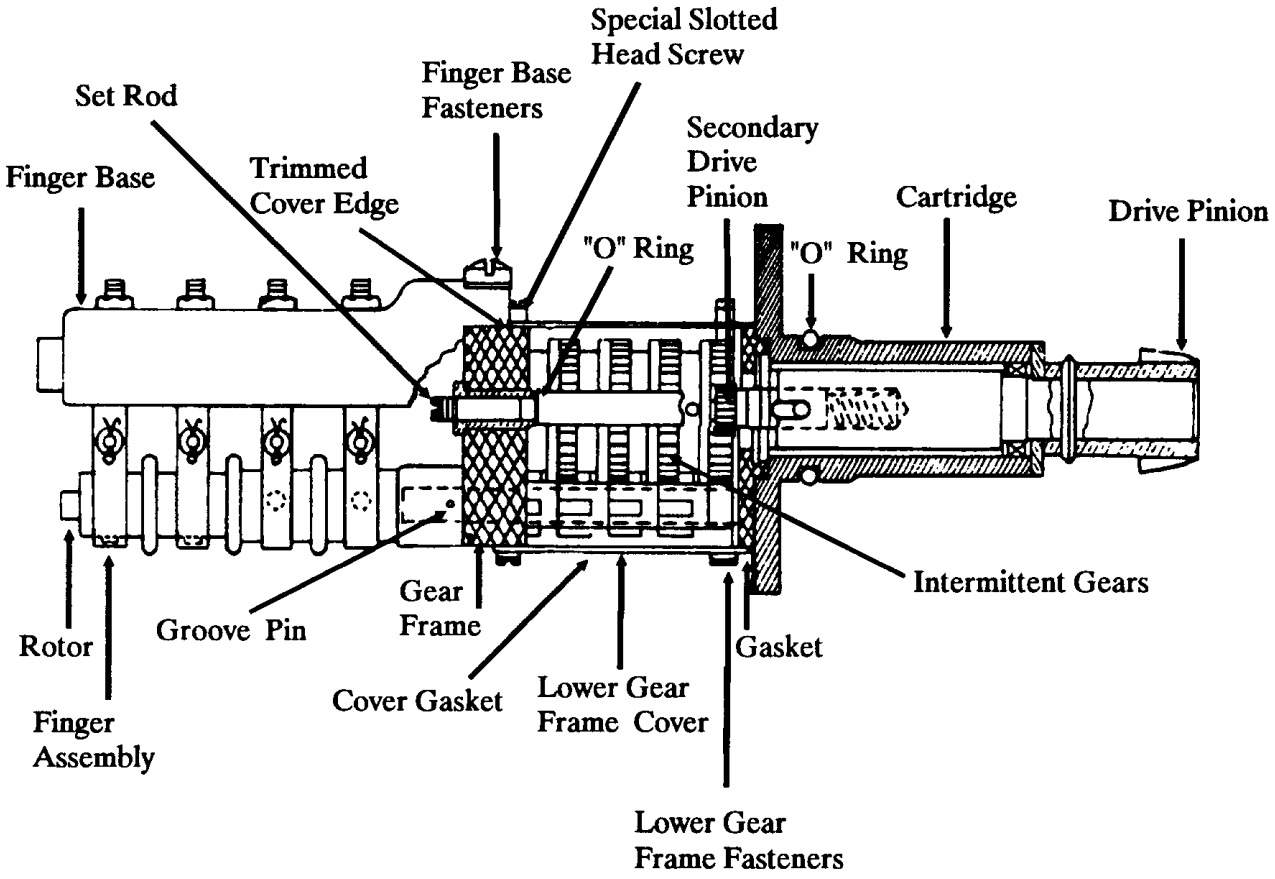
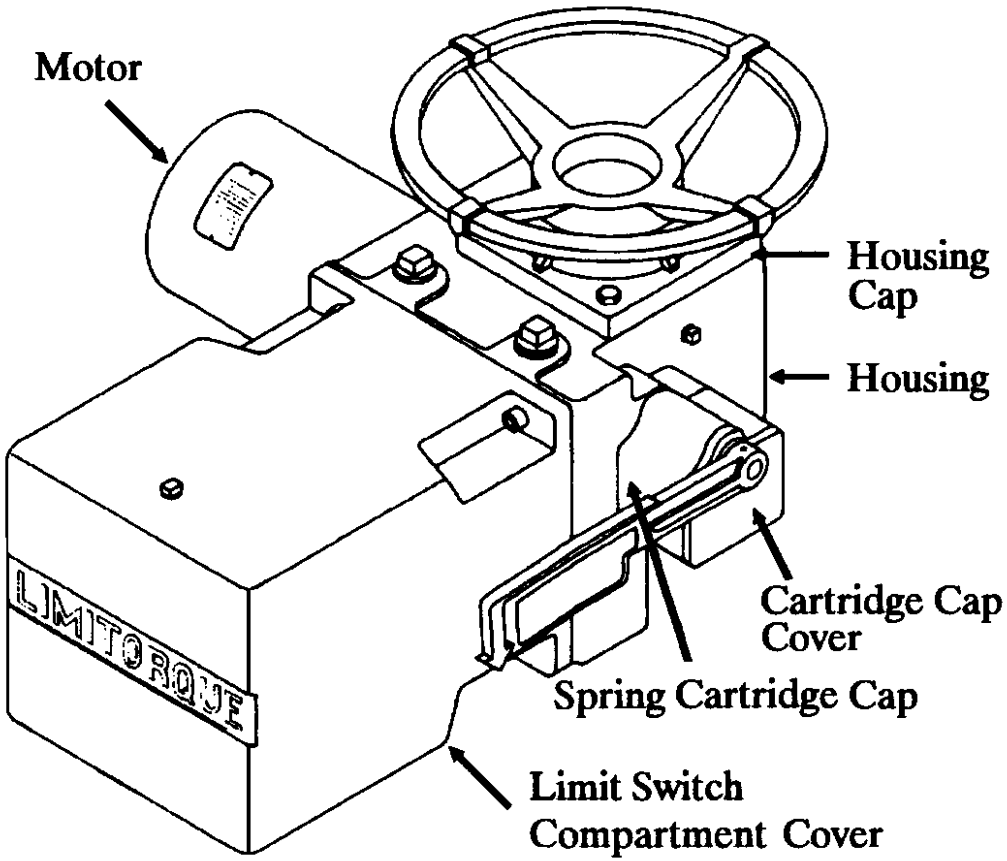
SMB-000/00 Limit Switch

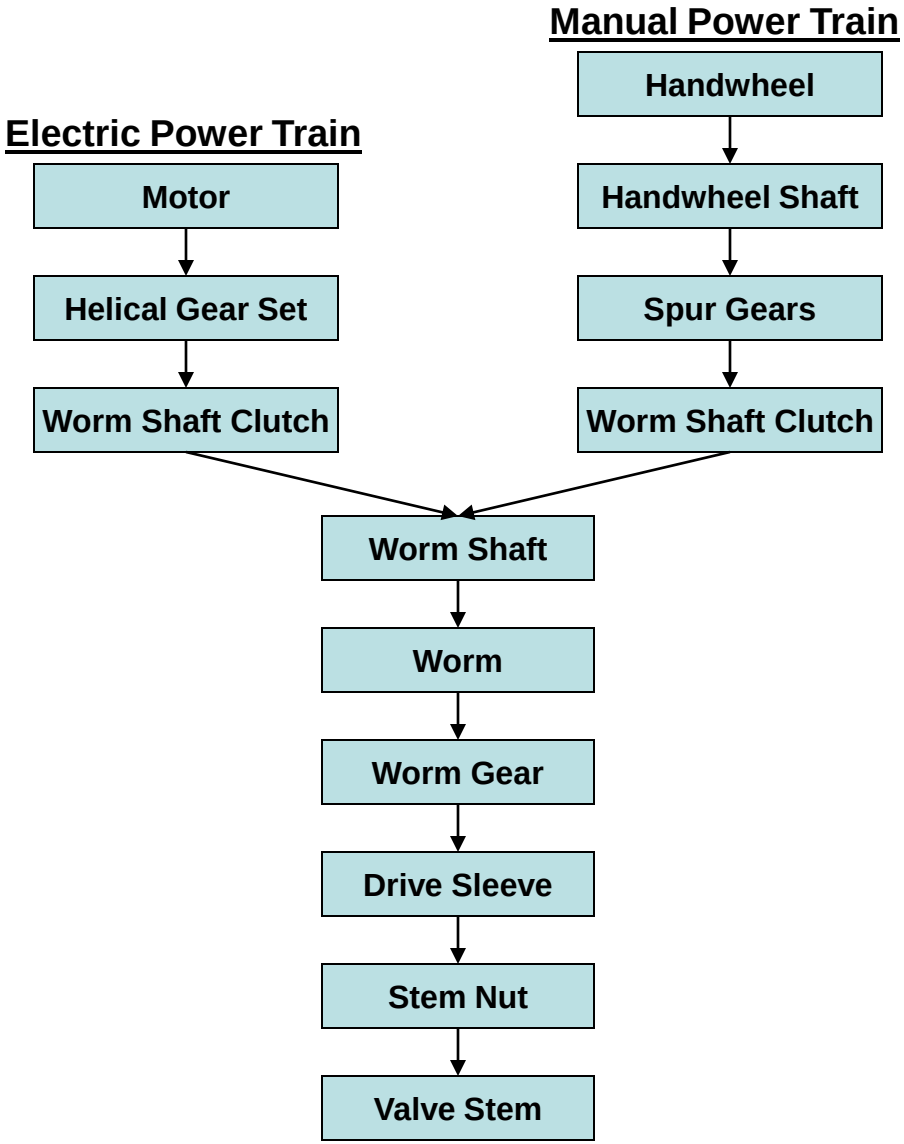


SMB-000 Housing

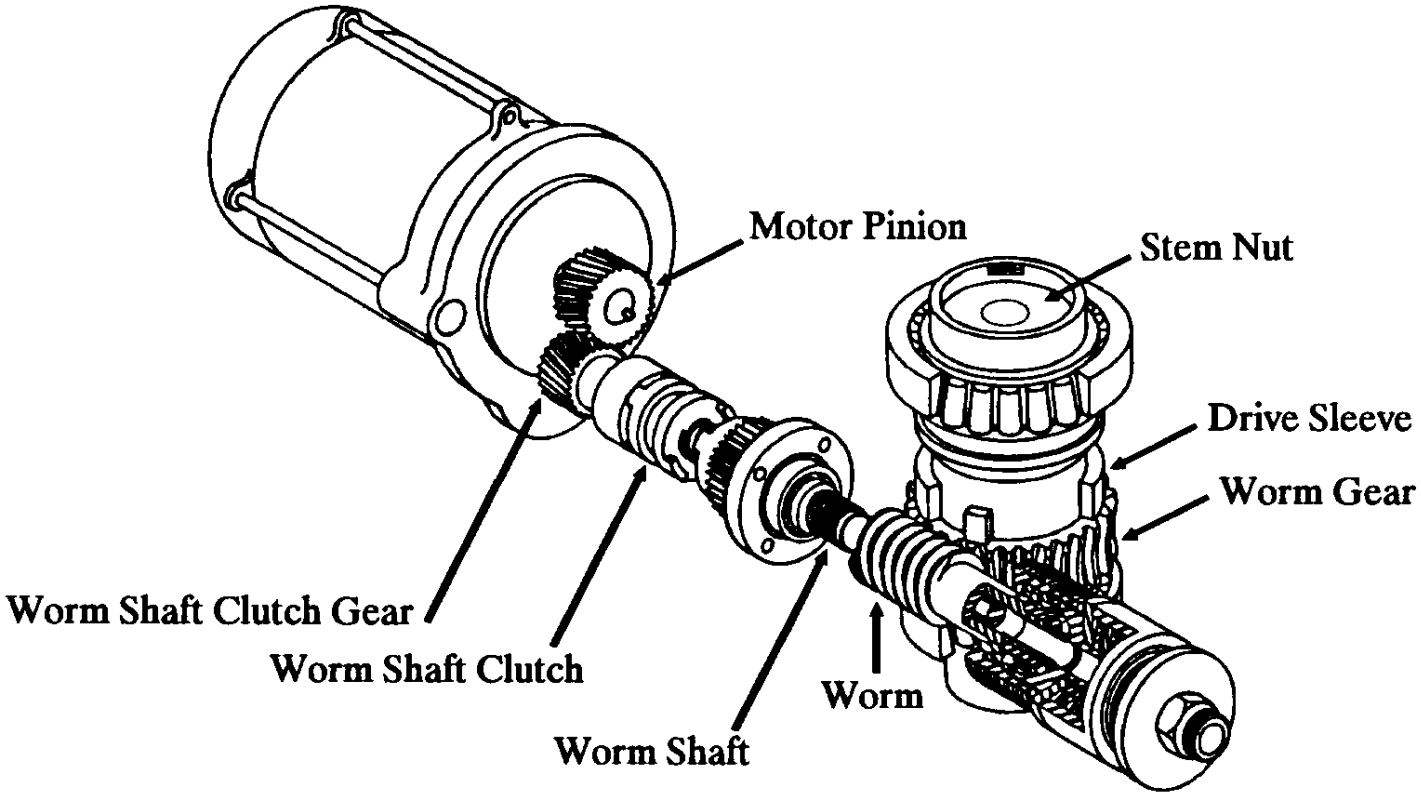


SMB/SB-0 thru -4

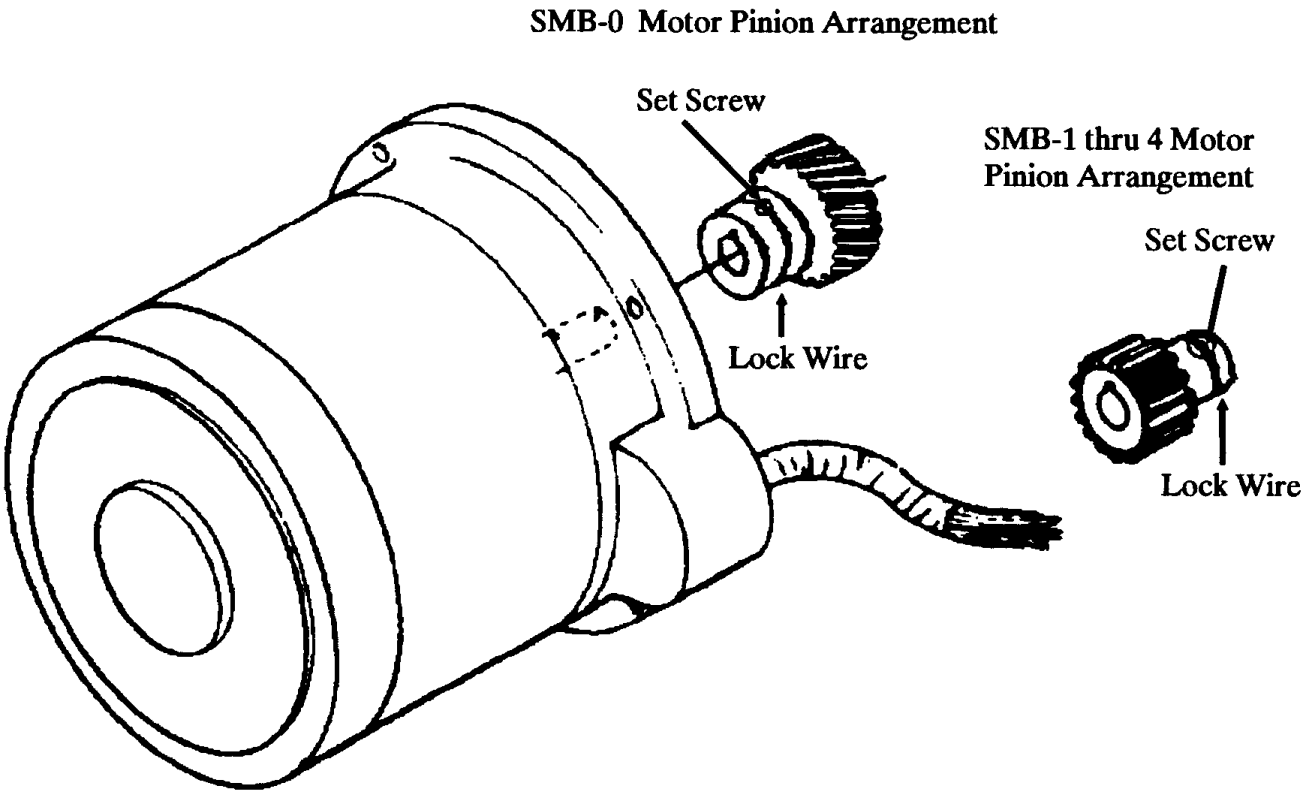
SMB-0 thru 4 Power Trains



SMB/SB-0 thru –4 Electric Power Train



SMB/SB-0 thru –4 Motor Pinion Arrangement



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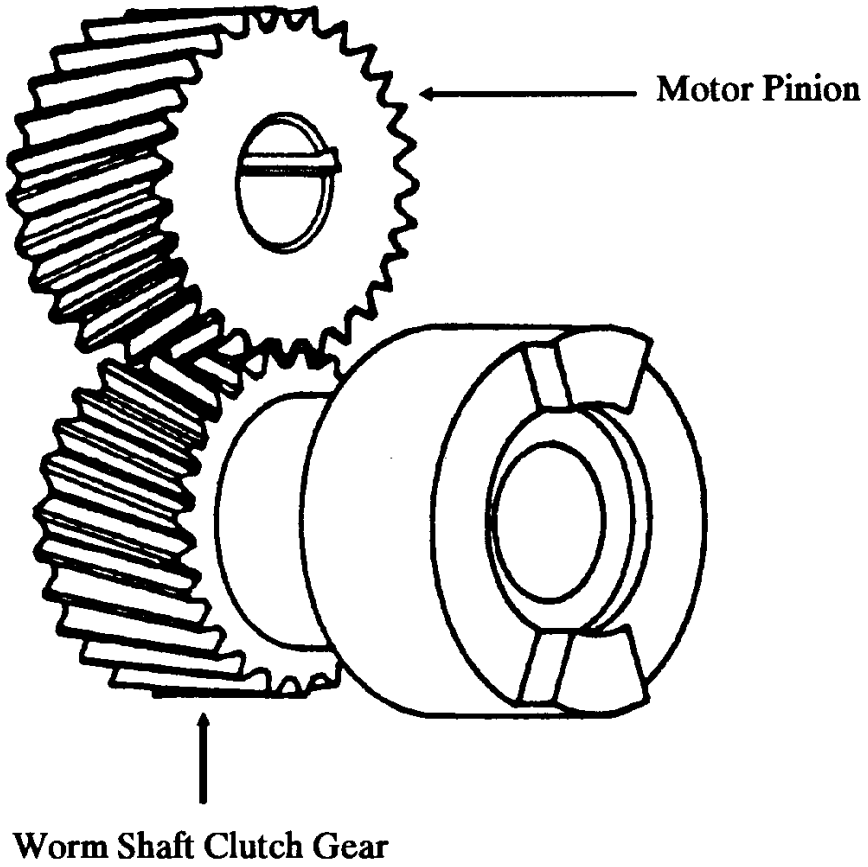
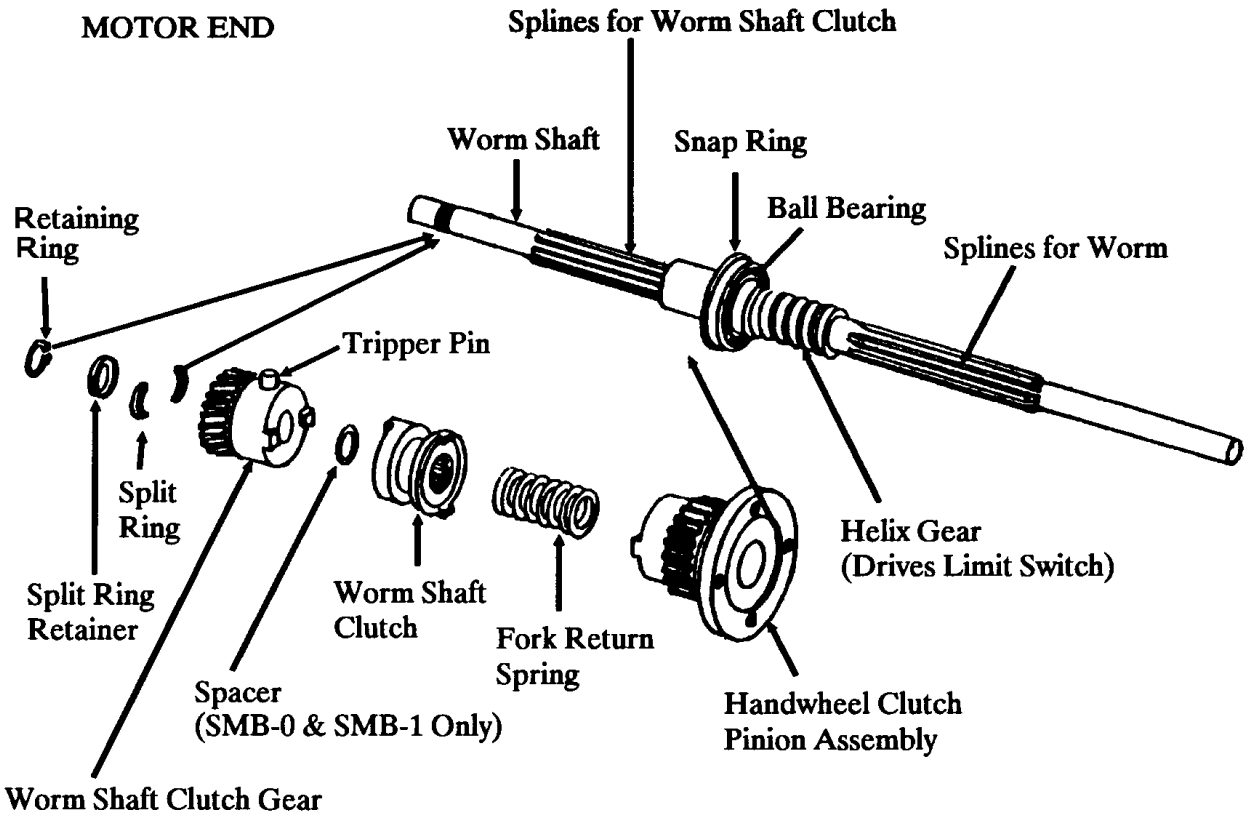
SMB/SB-0 thru –4 Worm Shaft Clutch Gear



SMB/SB-0 thru –4 Worm Shaft Exploded View



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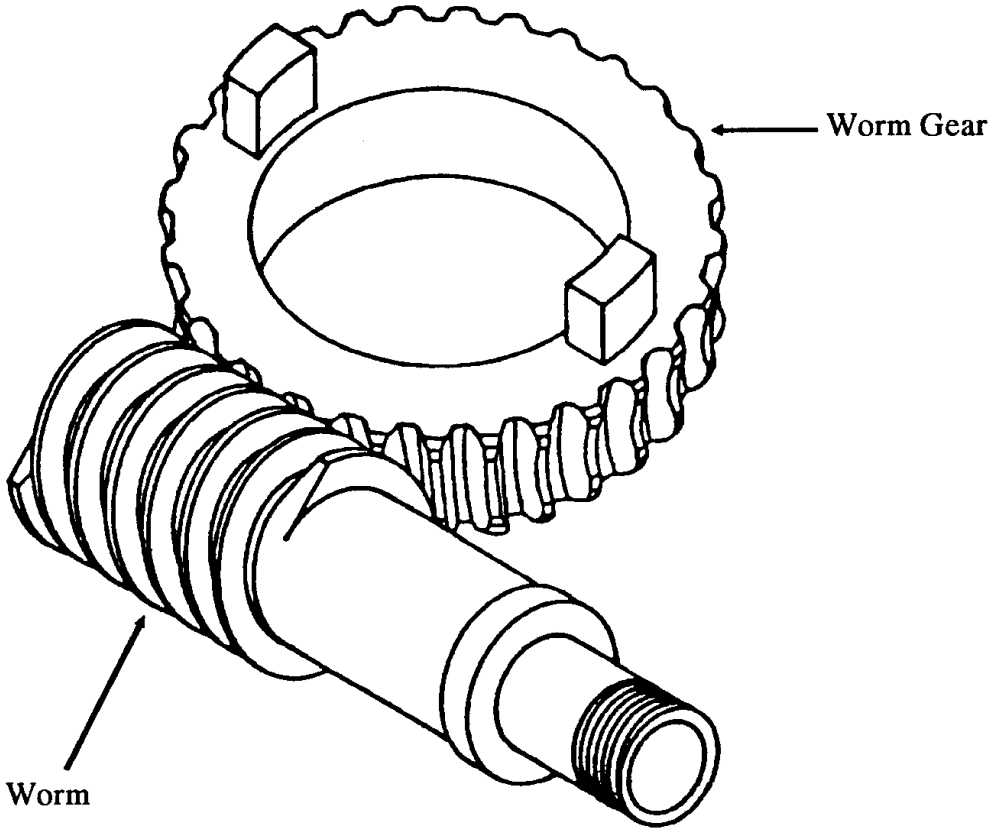
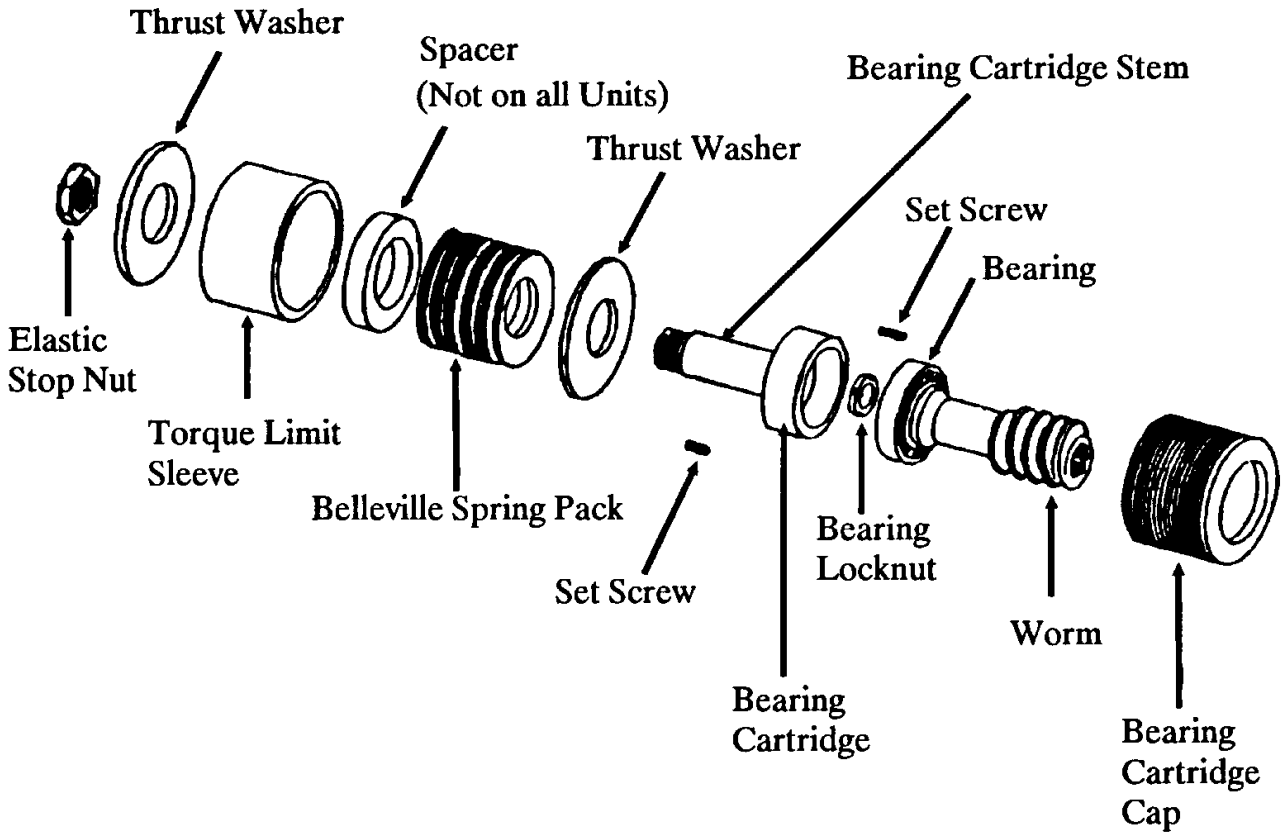
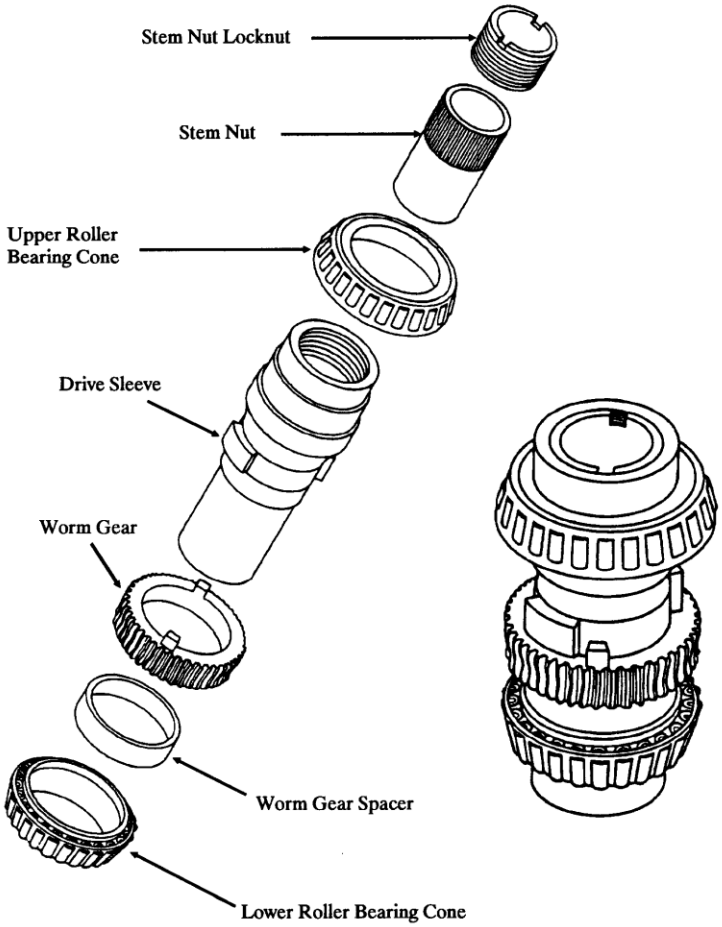
SMB/SB-0 thru –4 Worm and Worm Gear



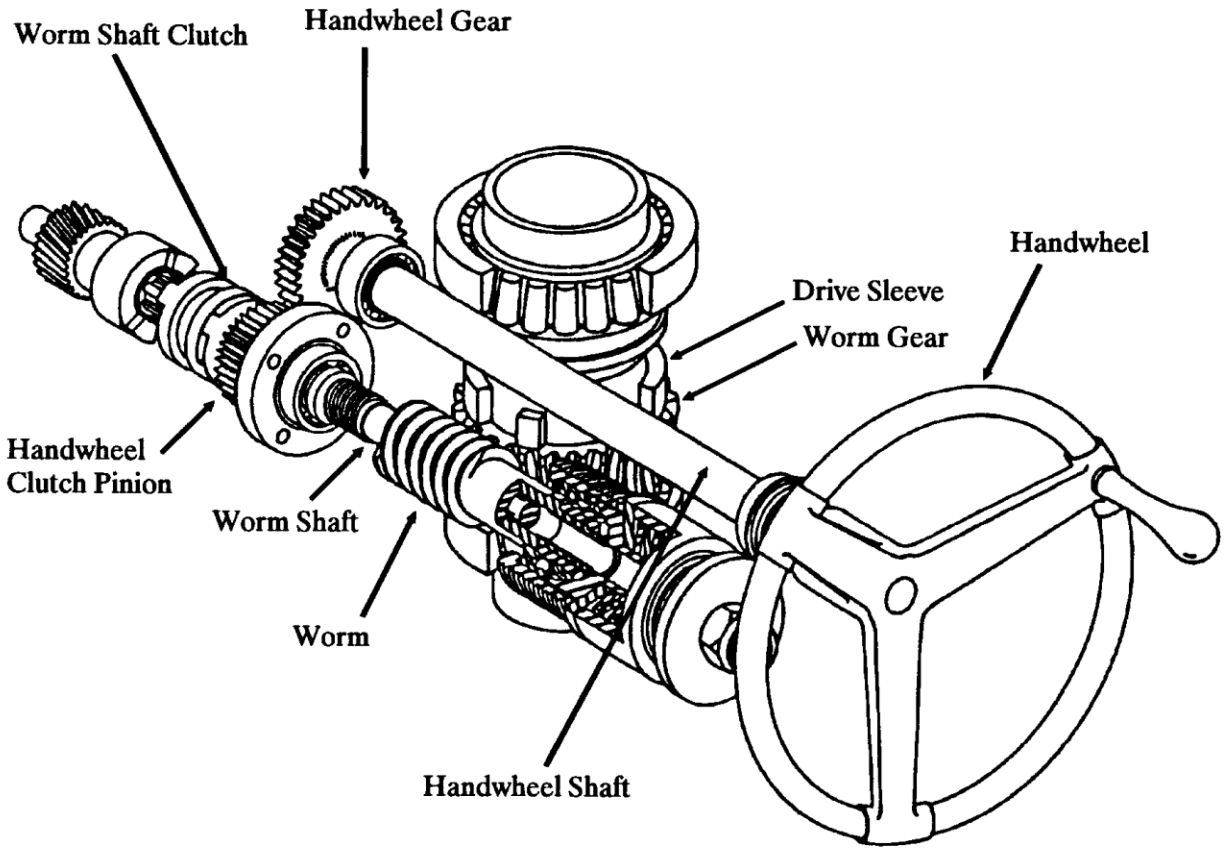
SMB/SB-0 thru –4 Spring Pack Assembly



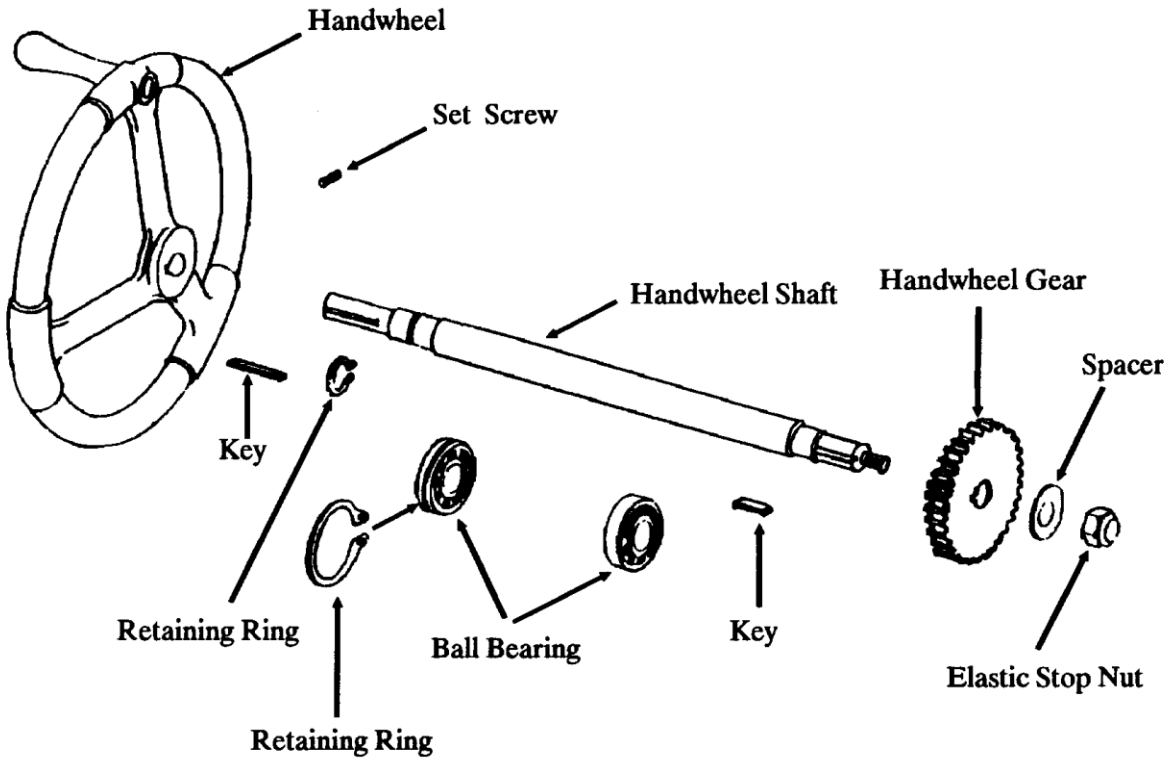
SMB/SB-0 thru –4 Drive Sleeve



SMB/SB-0 thru –4 Manual Power Train

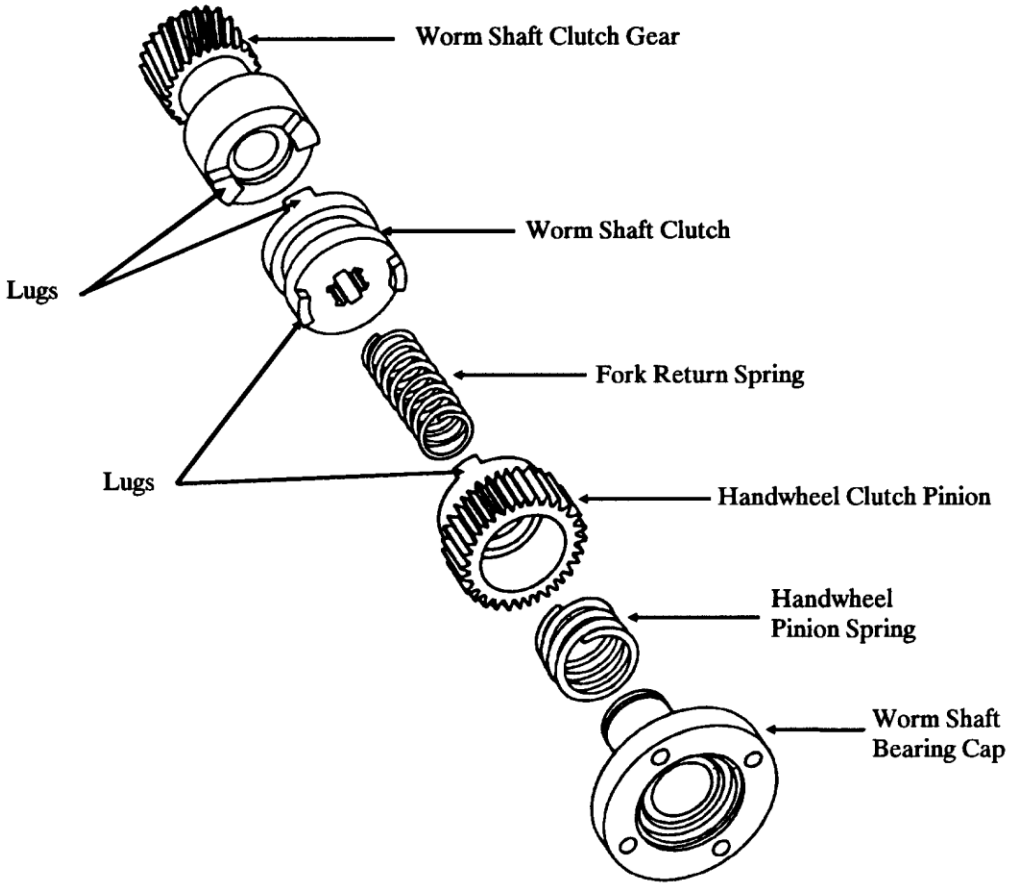


SMB/SB-0 thru –4 Handwheel Assembly

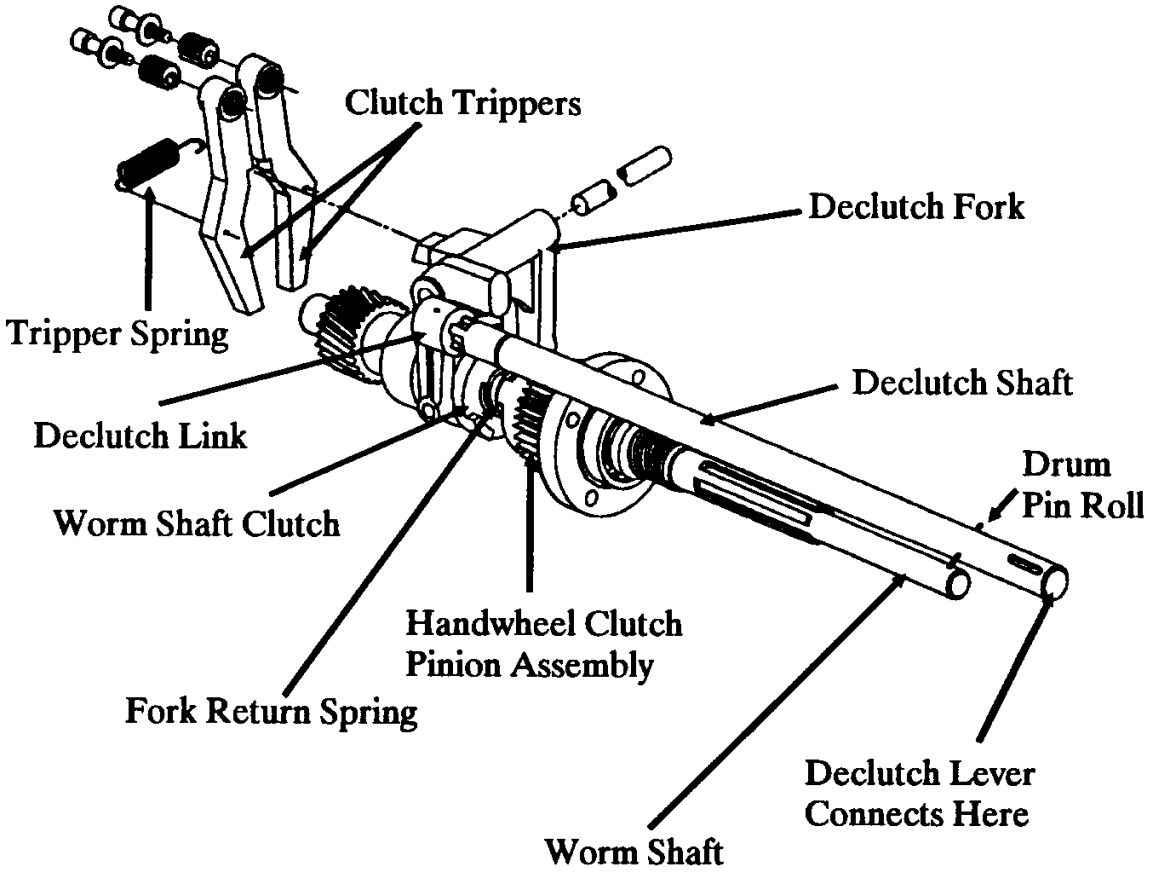


NOTE: SMB-3 and SMB-4 have needle bearings located in the cartridge cap for the handwheel

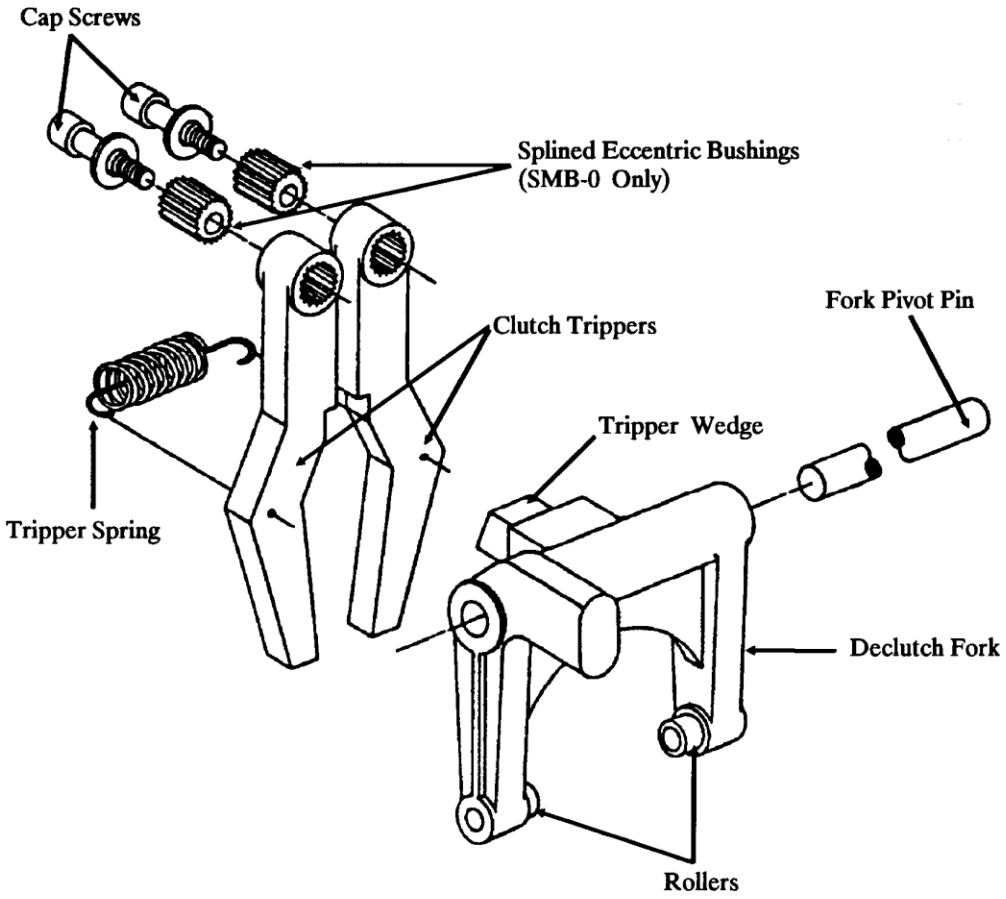
SMB/SB-0 thru –4 Worm Shaft Clutch



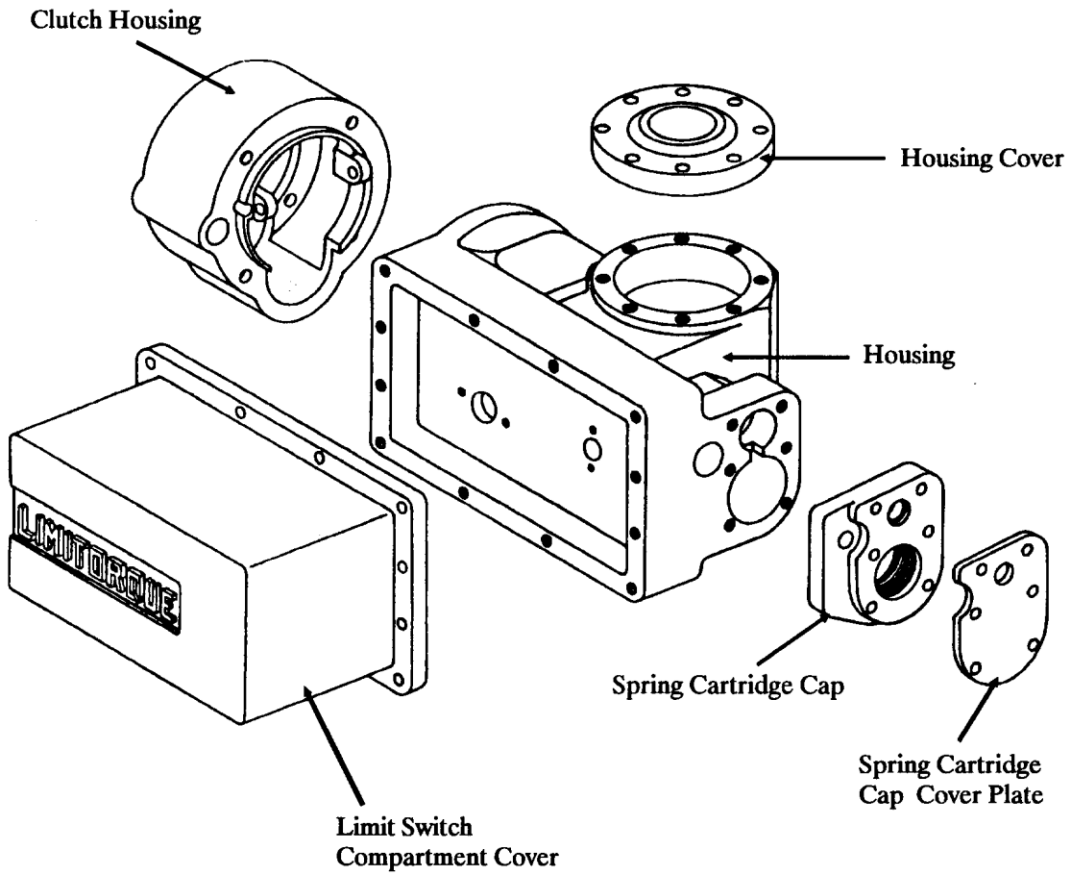
SMB/SB-0 thru –4 Worm Shaft and Declutch Mechanism



SMB/SB-0 thru –4 Declutch Mechanism

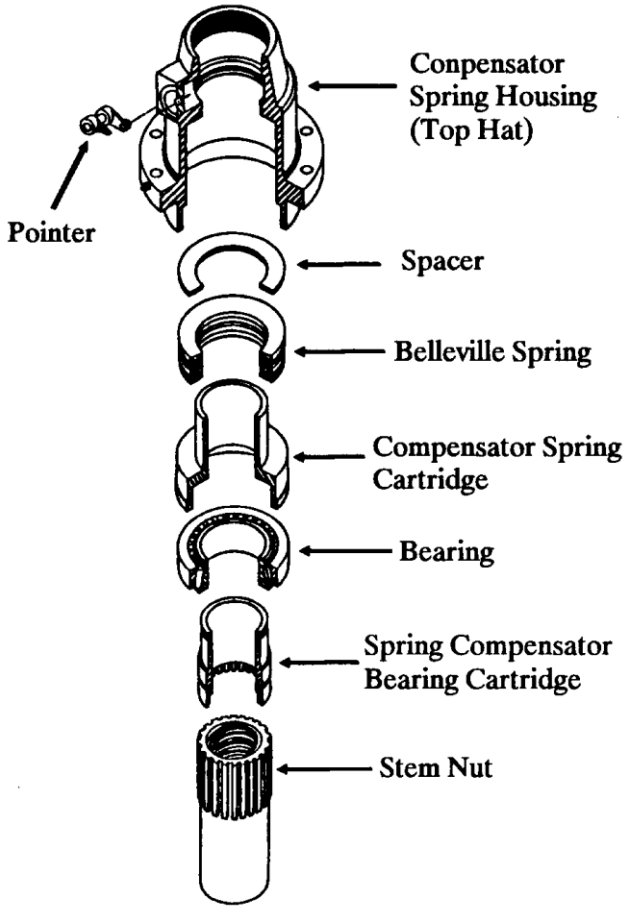


SMB/SB-0 thru –4 Housing



Limitorque SB Actuators

SB Belleville Spring Compensator Housing Cover Assembly



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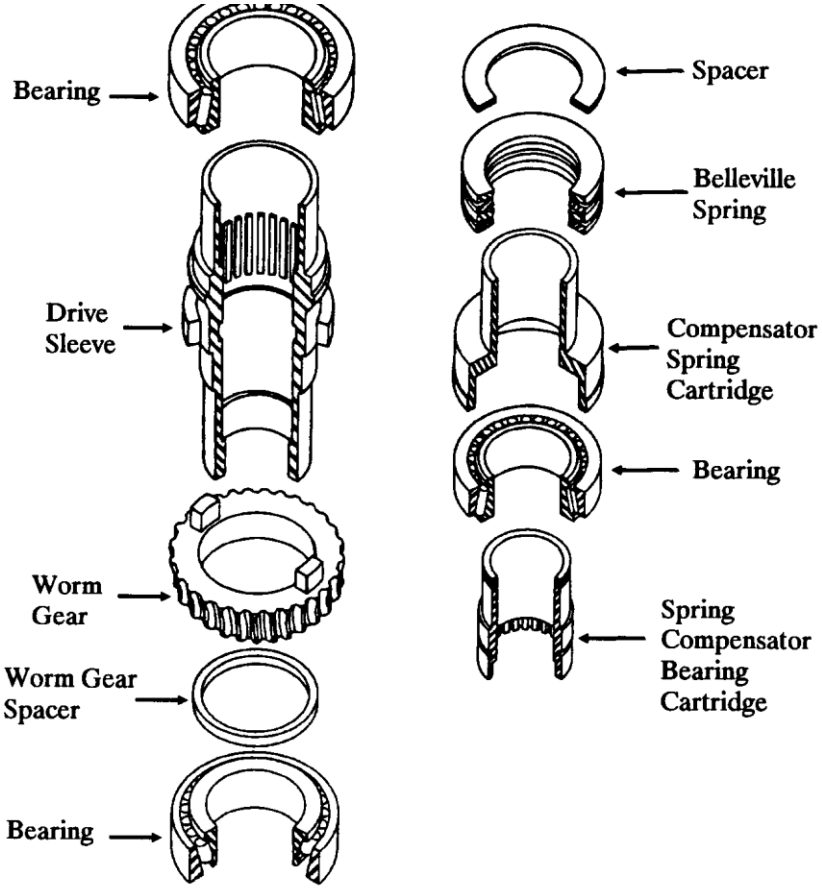
SB Spring Compensator



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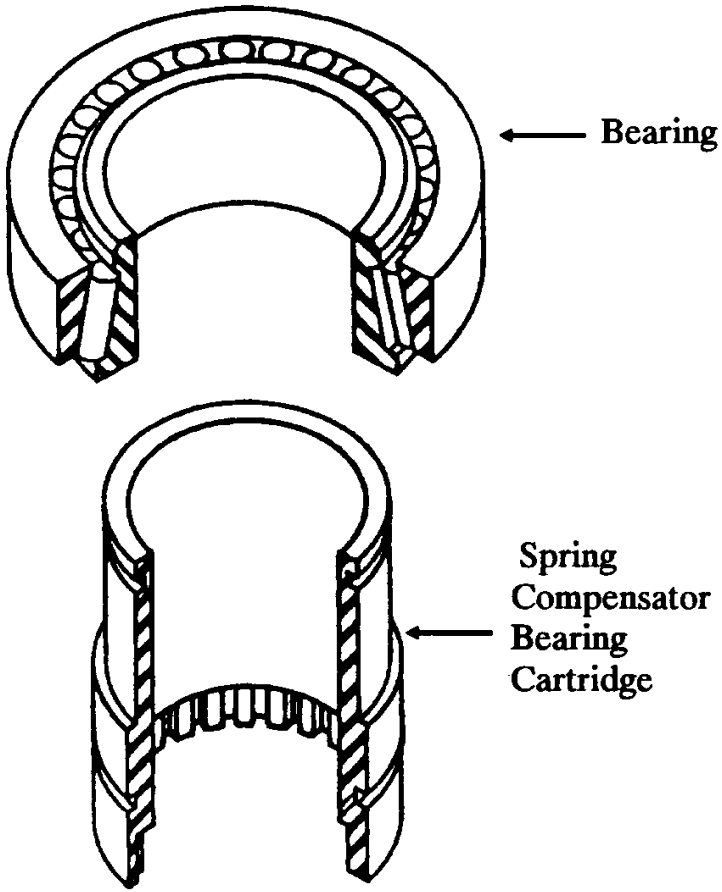
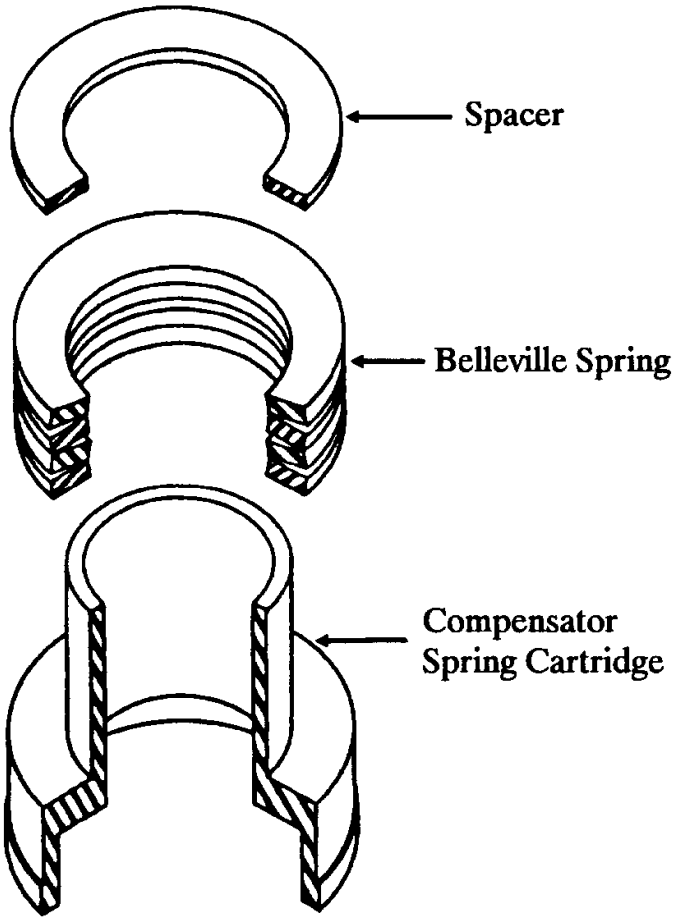
SB Belleville Spring Assembly With Bearing Cartridge



SB Belleville Spring Assembly With Spring Cartridge

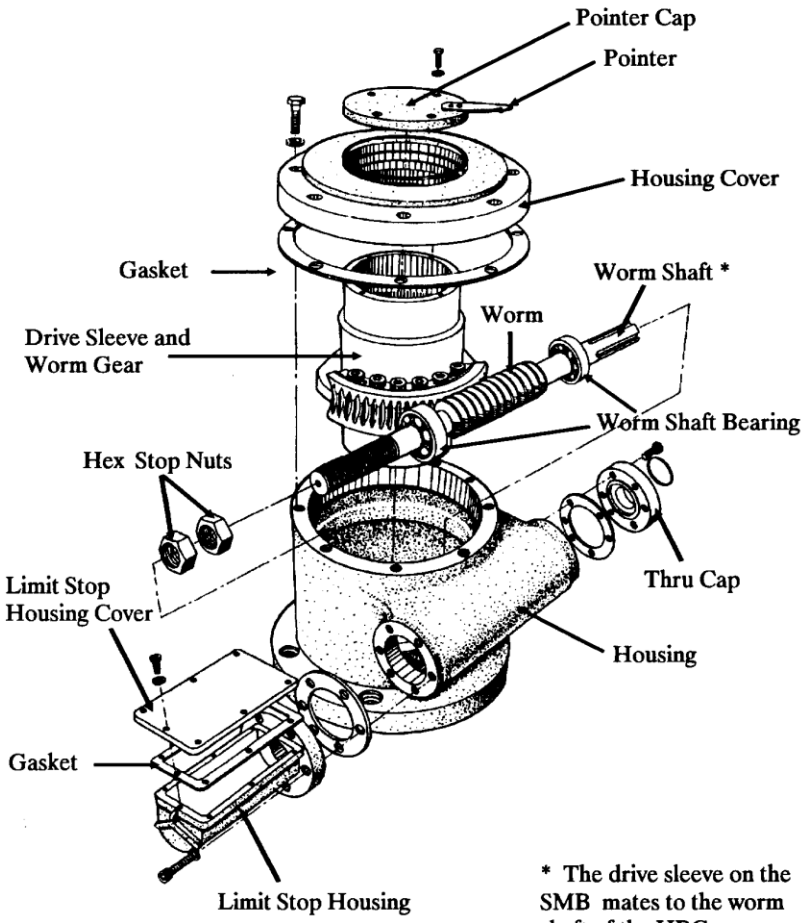


SB Spring Compensators

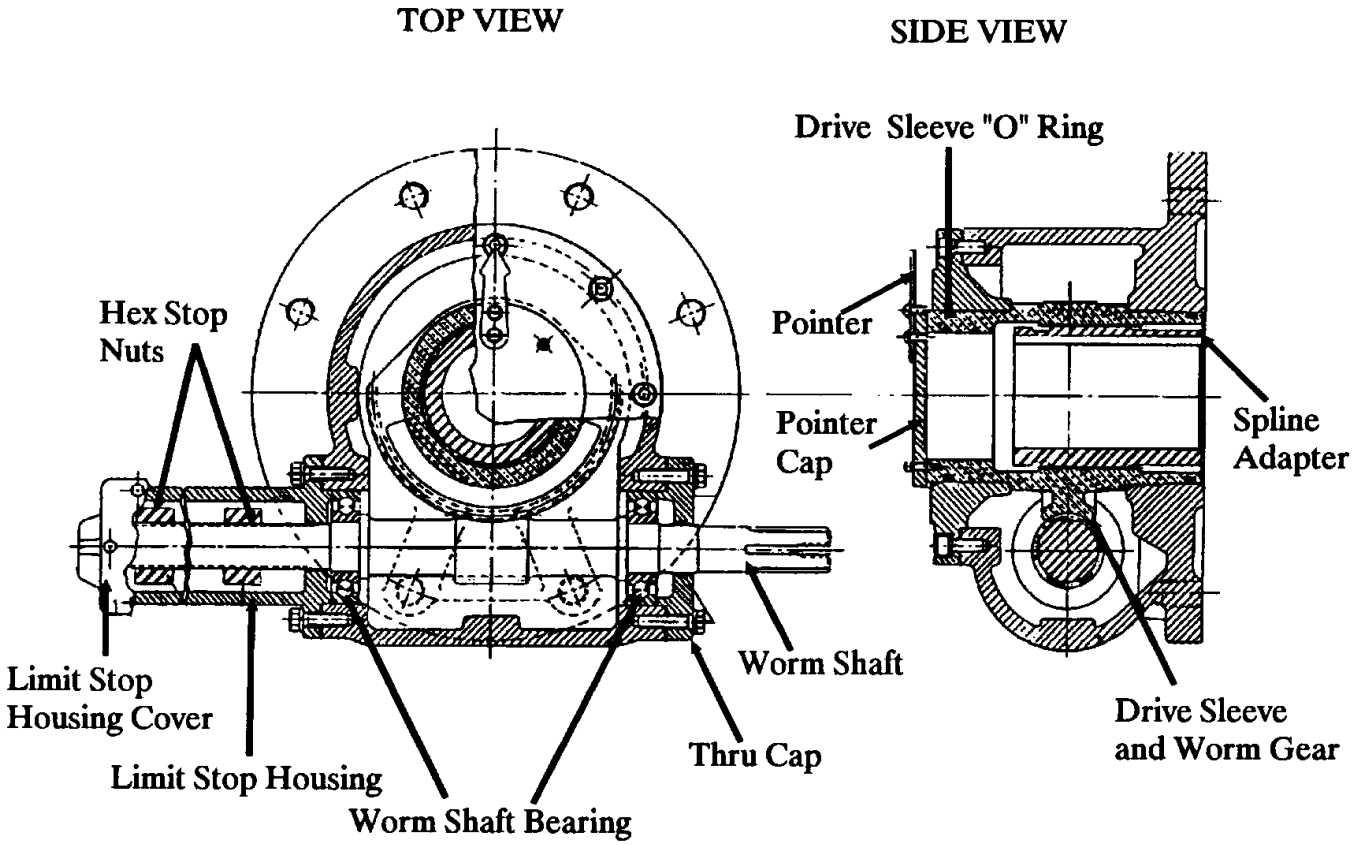
SB-0	4 Springs
SB-1	14 Springs
SB-2	5 Springs
SB-3	10 Springs
SB-4	4 Springs

HBC Actuator

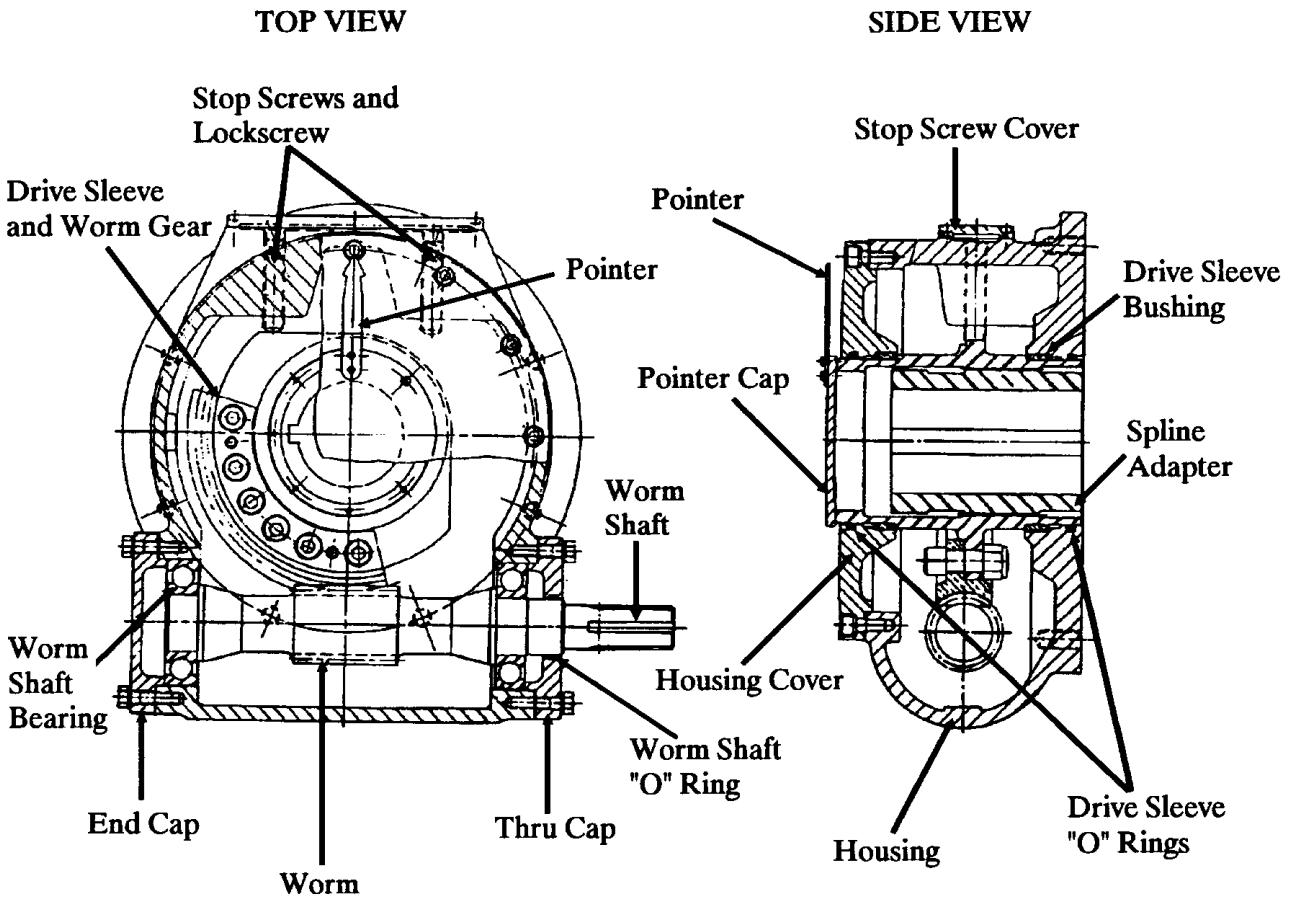
HBC –0 Thru 3 Exploded View



HBC –0 Thru 3 Operator Top and Side Views



HBC –4 Thru 10 Actuator



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Limitorque Lubrication

Limitorque Lubrication

- *Lubrication of the actuator internals is critical to the proper and sustained operation of the equipment.*
  - *Reduces wear*
  - *Removes heat*
  - *Resists moisture*
- *Major wear areas include*
  - *Bearings - drive sleeve, spring pack, and worm shaft*
  - *Sliding surfaces – drive sleeve splines, worm shaft splines, worm and worm gear teeth*
  - *Motor pinion and drive gear*

Limitorque Recommendations

- *For SMB and SB actuators*
  - *Not corrosive to steel gears, ball or roller bearings*
  - *Must contain an EP additive*
  - *No grit, abrasive or filler material*
  - *Suitable for the environmental temperature range*
  - *No separation at temperatures up to 300°F*
  - *Must not cause Buna-N or Viton to swell more than 8%*
  - *Good resistance to moisture*
  - *Good resistance to oxidation*

Recommended Lubricants

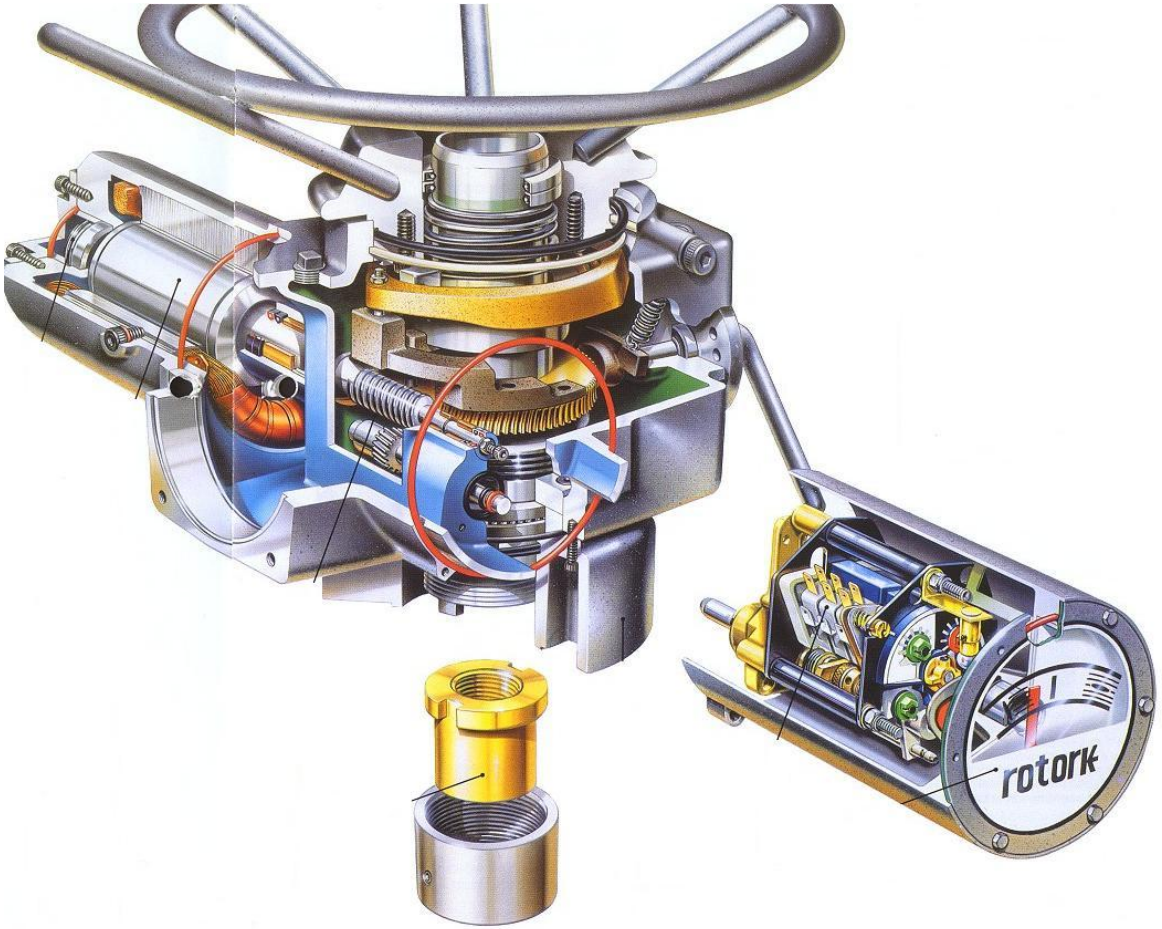
- *Exxon Nebula EP-0 for all units through SMB-4*
- *Prior to SMB/SB/SBD serial number 295809, Sun Oil Co. 50 – EP*
- *For Nuclear service inside containment, Exxon Nebula EP-1 is the only qualified lubricant.*
- *For limit switches, Beacon 325 or Mobil Mobilgrease 28 is used*
- *Lubricants should never by mixed.*

New Lubricants

- *Exxon Mobil has discontinued the manufacture of Nebula EP greases.*
- *Nuclear industry has identified the MOV Long Life grease for future use.*
- *ANSI bench tests have satisfied the Limitorque recommendations for actuator lubrication.*

Rotork Actuators

Rotork "A" Range Actuators



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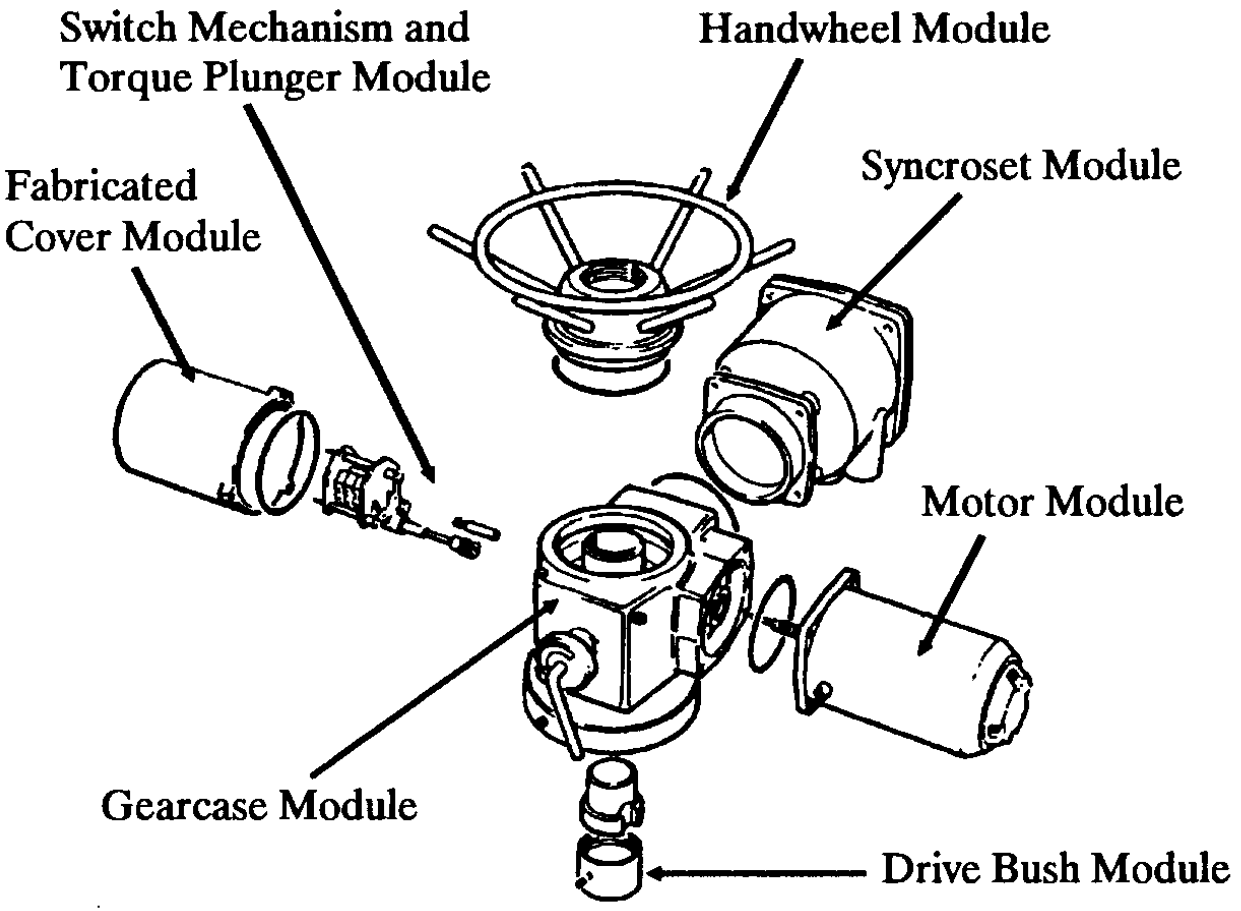
Rotork "A" Range Actuator

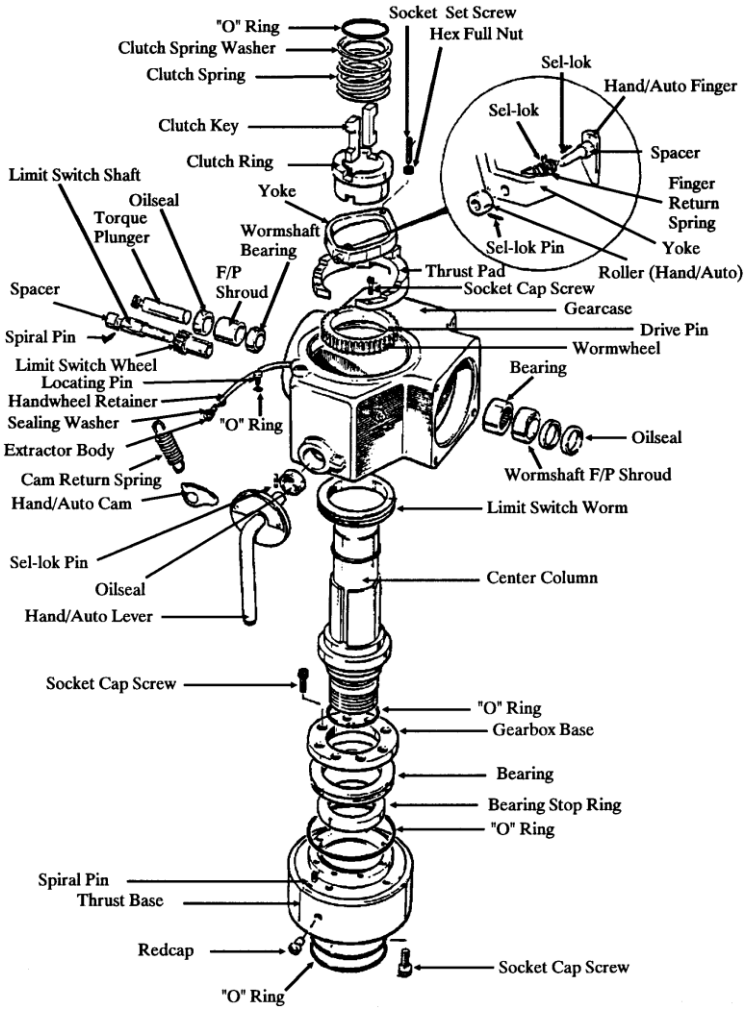


Rotork Actuator Size and Output Torque Values

Rotork “NA” type actuators are “A” Range actuators qualified for duty in nuclear power plants.

Torque, lb/ft at rpm								
Actuator	50 Hz: 18 60 Hz: 21	24 29	36 43	48 57	72 86	96 115	144 173	192 230
7NA	25	25	23	20	20	16	--	--
11NA	50	50	45	40	40	32	--	--
14NA	120	120	100	80	80	60	45	--
16NA	225	225	190	150	150	110	80	--
30NA	400	400	375	300	300	240	190	--
40NA	750	750	625	500	500	400	300	--
70NA	1100	1100	950	750	750	550	475	400
90NA	1500	1500	1250	1000	1000	750	640	540

Rotork Actuator Assembly



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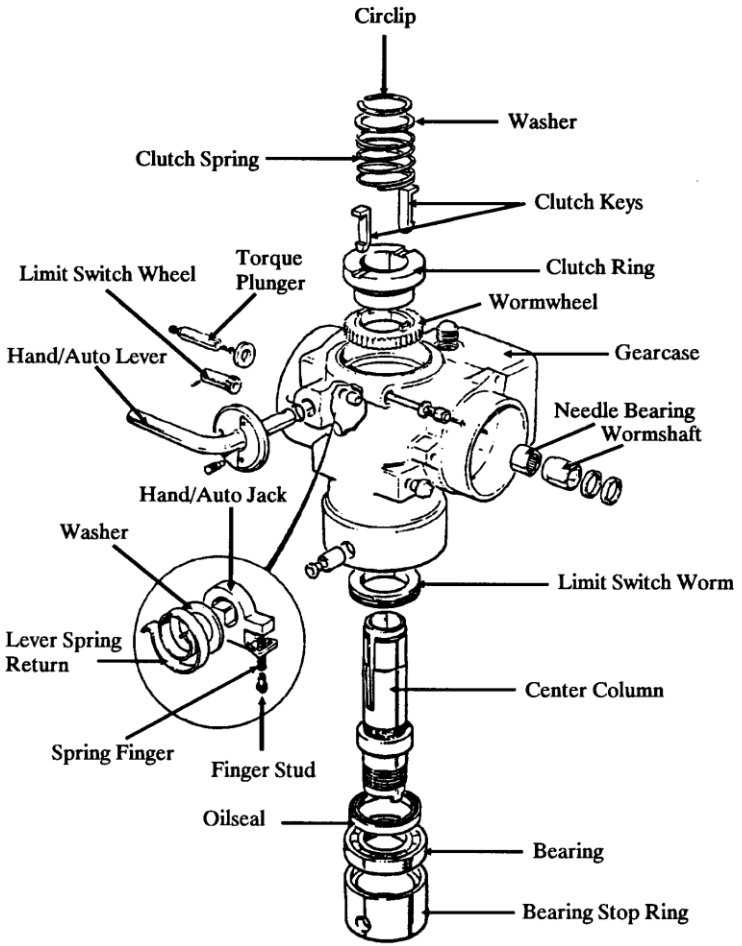
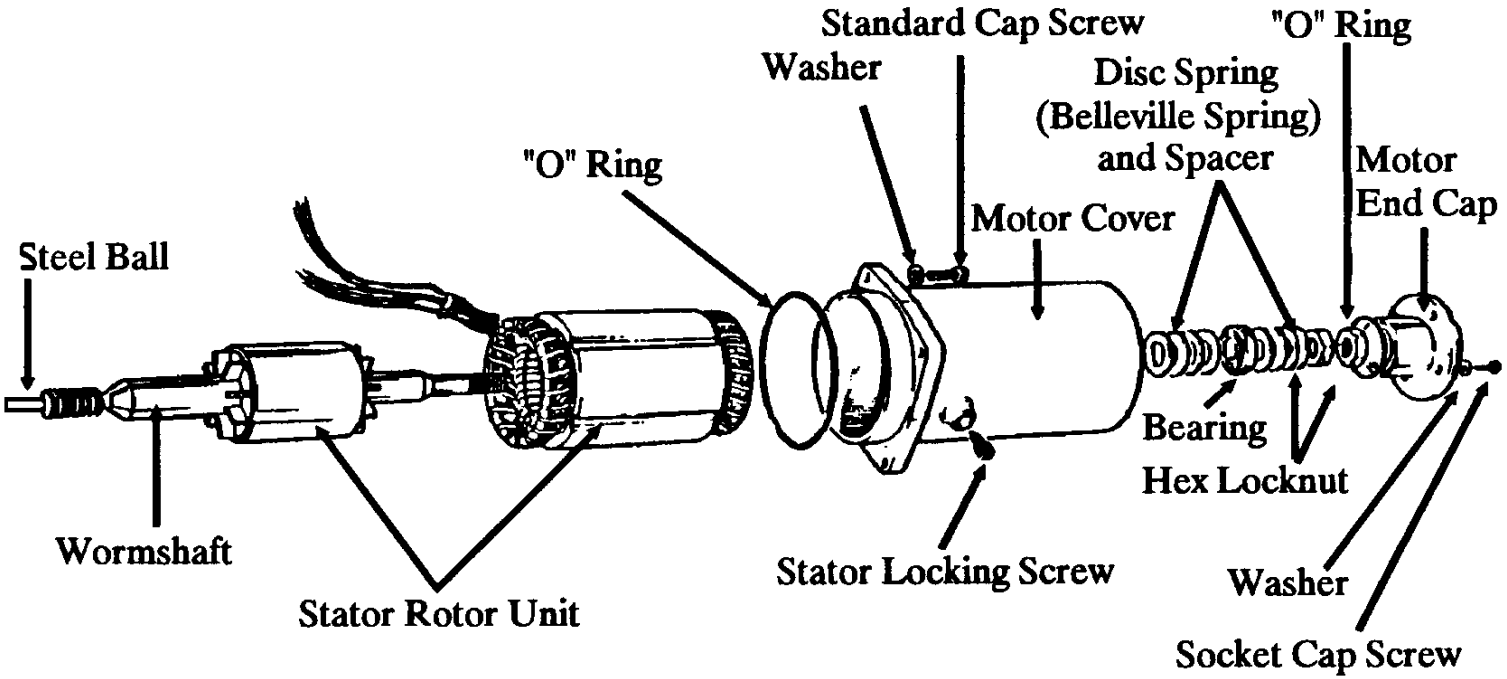
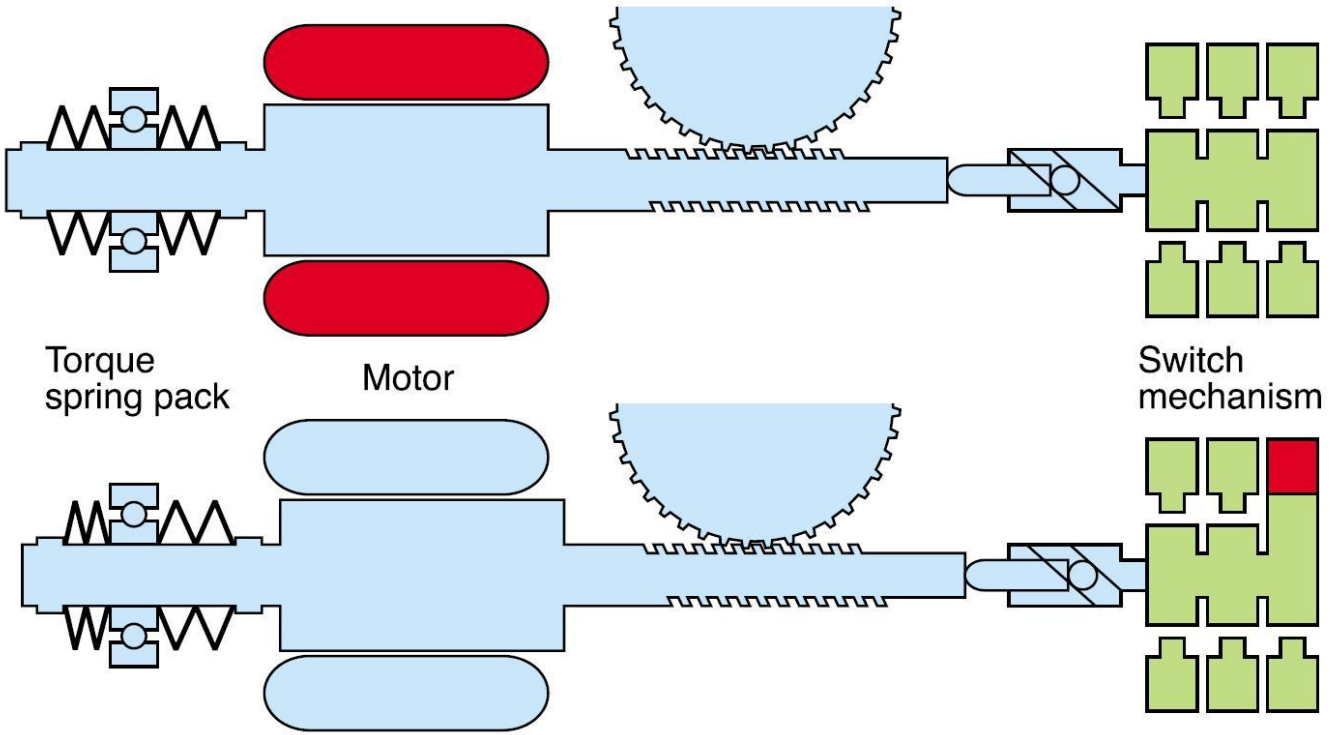
Rotork Category 1 Actuator



Rotork Stator Assembly



Rotork Torque Switch Mechanism



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Rotork Add-on Pak